Review Questions and Picture Studies in Physiography

BY

ALBERT L. AREY
Girls' High School (Retired)

FRANK L. BRYANT
Erasmus Hall High School (Retired)

WILLIAM W. CLENDENIN
Wadleigh High School

IN NEW YORK CITY

D. C. HEATH AND COMPANY

BOSTON NEW YORK CHICAGO
ATLANTA SAN FRANCISCO DALLAS
LONDON

Review Questions and Picture Studies in Physiography

BY

ALBERT L. AREY
Girls' High School (Retired)

FRANK L. BRYANT
Erasmus Hall High School (Retired)

WILLIAM W. CLENDENIN
Wadleigh High School

IN NEW YORK CITY

D. C. HEATH AND COMPANY

BOSTON NEW YORK CHICAGO
ATLANTA SAN FRANCISCO DALLAS
LONDON

2 H 8

PRINTED IN U.S.A.

FOREWORD

Several teachers using our *Physiography* have asked that, when our *New Physiography* was published, it be accompanied by a booklet containing the review questions that we have used in our classes, and that our methods of applying the principles of visual instruction to the study of the illustrations in the book be explained therein.

In complying with this request, we have made no effort to include questions on every illustration in the book that will repay the teacher for the time spent; we merely present several ways of beginning a discussion *by the pupils* of the lesson that the given illustration is expected to teach.

If the discussion is slow in starting, it may be necessary for the teacher to state some interesting fact bearing on the subject of the illustration, but we believe that it is not best for the teacher to do much talking during the discussion by the pupils. It usually pays better to talk only so much as is necessary to answer direct questions, and to guide the pupils to the points to be brought out, without permitting them to wander too far afield.

The best method is the one that arouses the most interest and leads to the most general discussion of the topic and to the comparison of related illustrations.

In our own classes this method has resulted in greater uniformity in the scholarship of the classes and has covered the ground with much less effort on the part of the teacher.

The following general guide to class discussion of textbook illustrations of physiographic features may be helpful.

With the textbook open to the illustration to be discussed, or with an enlargement of the illustration placed where every one in the class can see it, we start the discussion by calling upon a pupil to answer the first question below, following it with the others in about the order given:

1. What physiographic features are most prominent in this picture?
2. Mention the conditions or processes that formed the features named.

3. What physiographic agents have been active in the past, or are now active in forming the prominent features here shown?

4. If more than one agent may have been active, state which was probably more important.

5. Name any minor feature noticed. State necessary conditions and processes concerned in bringing about each particular feature named.

6. Point out the relation between the tearing-down processes and the building-up processes in the region illustrated.

7. What human interests do you think are influenced by the changes shown in the picture?

8. Has any pupil a question that will lead to a better understanding of the activity illustrated?

We do not require notes to be taken by the pupils but do not forbid them to take brief notes if they feel that they will not remember what they have learned.

Experience has taught us that this method will start discussion by the pupils in which they will be interested and from which they often obtain much information; furthermore *the teacher will get the pupils' point of view.*

MAY, 1928 THE AUTHORS

TABLE OF CONTENTS

REVIEW QUESTIONS

CHAPTER I

THE EARTH IN SPACE

1. What is the cause of the apparent passage of the sun through the sky each day?

2. What makes the sun appear to move from the east to the west?

3. How many degrees does the sun appear to move each hour? How long does it take the sun to appear to move one degree?

4. How many miles does the earth at the equator actually rotate each day? How many miles each hour?

5. What are three of the best evidences that the earth's surface is curved?

6. When are the lengths of day and night equal at all places on the earth?

7. How much does the longest day in summer differ from the shortest day in winter in the locality where you live?

8. At places farther north is this difference in the length of days greater or less?

9. Where, when, and why are the lengths of day and night unequal?

10. How long does it take the earth to go round the sun? What is this motion called? What is the path that it follows called?

11. About how many miles a day does the earth travel in its orbit?

12. What would be the length of our day and night if the period of rotation were equal to a period of revolution?

13. What is considered the principal cause of our change of season? Why is the change regular?

14. What effect upon the change of seasons would a greater inclination of the earth's axis have? A less inclination? No inclination from a perpendicular to the plane of the earth's orbit?

15. What determines the length of our seasons?

16. What is meant by the solstices and equinoxes? Give the dates of occurrence.

17. On what dates does the sun rise due east and set due west of an observer? Between what dates does it rise north of east and set

north of west? Between what dates does it rise south of east and set south of west?

18. Where on the earth are the sun's rays vertical at the dates given for solstices and equinoxes?

19. Does the sun's daily path through the sky shift north or south from December 21 to June 21? During this six-months period what change in the length of days is taking place in the northern hemisphere?

20. What determines the position of the tropic and the polar circles?

21. What is meant by the expression "Land of the Midnight Sun"? Where is it?

22. Where on the earth does the sun rise once a year and set once a year? Give the dates.

23. How long at this location does the sun stay above the horizon? How would an observer be able to tell when he had reached this point?

24. Why is the sun not always the same distance from us?

25. With the aid of a protractor it is possible to make an estimate of the time of exposure of the photographic plate from which Figure 8 of the textbook was made. Explain how this might be done.

CHAPTER II

LATITUDE, LONGITUDE, AND TIME

1. Define latitude, and explain why the length of the latitude degree is not the same everywhere.

2. Give the approximate length of the latitude degree at the equator, and tell where the latitude degree is shortest and where longest. By how many miles does it vary?

3. Define longitude and degree of longitude at any place; and explain why the length of the longitude degree varies.

4. Give the approximate length of the longitude degree at the equator. By how many miles does it vary on the earth?

5. Explain the analogy between locating a house in the city by the streets and avenues and locating a ship at sea by latitude and longitude.

6. Define *perpendicular, vertical, horizontal, zenith, horizon, altitude* of a heavenly body, *declination* of the sun.

7. How does a ship's officer find the latitude of his ship by day? By night?

8. In order to locate the ship, longitude must be found at the same moment. How is this done?

9. Suppose the sky is cloudy or the ship is in a fog. How then is a ship at sea located?

10. (*a*) How could you lay out a true north-south line by means of the sun? (*b*) How by the North Star? (*c*) How could you get the noon altitude of the sun? (*d*) How is the altitude of Polaris determined?

11. Why is it that the shortest shadows do not always fall when watches and clocks read noon?

12. Correct time is determined by astronomical observatories on clear nights. Why is this necessary?

13. Time service is now given the public by radio at different times of the day and by telegraph, usually at noon. How is this correct time obtained?

14. Why is it that the sun is not a good timekeeper?

15. Explain the meaning of A.M., P.M., and M.

16. Where on the earth do the days of the week first start, and in what direction do they travel?

17. (*a*) When it is 9 A.M., May 1, at New York, 75° west longitude, what is the day and hour at 165° west? (*b*) At 120° east? (*c*) Explain why it is necessary to omit a day in crossing the 180th meridian going west, and to repeat the date in crossing it going eastward.

18. (*a*) Those who live on the time meridians have the same local time and clock time. (*b*) If you live on the seventy-fourth degree meridian west, what would be your local time and your clock time when it is noon in Chicago?

19. When it is noon in New York City, what is the time in San Francisco? In London?

20. When Colonel Lindbergh flew across the Atlantic Ocean from New York to Paris, was the night for him longer or shorter than at either of these cities? Explain.

21. What is the International Date Line, and what adjustments of time are made in crossing it?

22. What is meant by *leap year*, and why is it necessary?

23. What is the name of the calendar we now use, and what are its advantages over the Julian?

24. How should you arrange a calendar with all the months the same length?

25. How do the paths of sun, moon, and stars, because of the

rotation of the earth, stand with reference to the horizon of: (*a*) An observer at the equator? (*b*) An observer at the poles? (*c*) An observer in any other latitude?

26. (*a*) How is the "daylight circle," the line separating the lighted from the unlighted hemisphere, situated with reference to the rays of the sun? (*b*) How does the daylight circle divide the equator? (*c*) How does it divide the parallels in the summer hemisphere; in the winter hemisphere? (*d*) When, if ever, does the daylight circle bisect all parallels? (*e*) Express this division of equator and parallels in terms of length of day and night.

27. Determining longitude is always a comparison of times, one of which is of a place of known longitude, usually of Greenwich or zero longitude. The time of the prime meridian is carried on the chronometer of the ship, and local noon is determined. If the chronometer is *faster* than local time, the longitude of the place is *west;* and if the chronometer is *slower,* the longitude of the place is *east. Example.* Noon by the ship and 4 A.M. by chronometer: the ship is 8 hours or 120° east of the prime meridian, or in 120° east longitude. Find the longitude of a ship whose chronometer shows 4 P.M. when it is noon by the ship.

28. Define solar day, lunar day, and sidereal day. Explain why the sidereal day is measured by rotation of the earth through 360°, the solar day by rotation through about 361°, and the lunar day by rotation through about 373°.

29. The earth is moving fastest in its orbit at perihelion. Why? Therefore the solar day is longest at that time and shortest at aphelion. No two consecutive solar days are of equal length; therefore our clocks keep *mean* or average solar time. Will the sun come to the meridian before or after 12 by the clock in midwinter? In midsummer?

30. (*a*) Why do twilight and dawn last for a shorter time at the equator than in New Orleans? (*b*) Why longer in London than in St. Louis? (*c*) Make a general statement regarding the length of twilight and dawn in their relation to the latitude of a given location.

31. (*a*) Why do the stars rise about four minutes earlier each night than the night before? (*b*) A star that rises at 6 A.M. will rise about what hour three months later? In what part of the sky will it then be seen at 6 A.M.?

32. Explain the location of a ship by "dead reckoning." Explain its location by radio.

CHAPTER III

THE MOON

1. Compare the moon and earth as to: (*a*) Size, (*b*) motions, (*c*) source of light, (*d*) suitability for life. (*e*) How much of the moon is always illuminated?

2. How fast, measured in degrees, is the moon moving in its orbit about the earth? In what direction is it moving?

3. Compare the mountains and valleys of the moon with those on the earth.

4. Compare the length of day and night on the moon with the length of day and night on earth. To what is the difference due?

5. (*a*) Why does the distance of the moon from the earth vary? (*b*) What is the approximate distance of the moon from the earth? (*c*) Give the names for the points in the moon's orbit nearest to and farthest from the earth.

6. Why does the moon change phase, and how long does it require for the moon to go through its cycle of phases?

7. How often do we have full moon? Explain.

8. What is an eclipse?

9. Compare the duration of an eclipse of the sun with that of the moon. Explain the difference.

10. Astronomers often travel thousands of miles to study a total solar eclipse. Why is it considered so important?

11. What is meant by *lunar day*, and why is it longer than a solar day? About how much longer is it?

12. The period required for the moon to go through its cycle of phases is the *lunar month*, analogous to the earth year. (*a*) Why is this period longer than the time required for a complete revolution of the moon? (*b*) Give the number of days for each.

13. (*a*) About how long after new moon is the moon in first-quarter phase? (*b*) Where do we see the first-quarter moon when the sun is setting?

14. (*a*) How do you distinguish between the young crescent and the old crescent moon? (*b*) How between the first-quarter and the third-quarter moon?

15. (*a*) In what part of the day or night do we see the first- and

third-quarter moon? (*b*) At what phase of the moon is it of greatest value as a source of light? (*c*) Why?

16. Between what phases of the moon is it *waxing* and *waning?* How can you tell a waxing from a waning moon?

17. (*a*) About what time of day does the full moon rise? (*b*) Where do we see the full moon at midnight?

18. (*a*) Why do we never see the new crescent moon in the east nor the old crescent moon in the west? (*b*) Why are we able to see the entire outline of the moon at new crescent and old crescent phases?

19. (*a*) How do we know the moon rotates? (*b*) Give the period of rotation.

20. (*a*) What is a *shadow?* (*b*) Why do the earth and moon cast shadows? (*c*) What is the position of these shadows with reference to the sun? (*d*) Why are these shadows *cone-shaped?*

21. (*a*) Do we ever get into the earth's shadow? (*b*) If so what do we call this phenomenon? (*c*) What do we call the phenomenon of being in the moon's shadow? (*d*) At what phase of the moon do we get into its shadow?

22. (*a*) Explain lunar eclipses. (*b*) Why does a lunar eclipse occur only at full moon? (*c*) Why is there not a lunar eclipse every full moon?

23. There are more solar eclipses than lunar; yet you will not see so many solar as lunar. Why is this?

24. If the *umbra* of the moon's shadow reaches the earth, there will be a total eclipse of the sun; but if it does not reach the earth, there is an *annular* eclipse. Why should the shadow sometimes reach the earth and sometimes not?

CHAPTER IV

THE SOLAR SYSTEM

1. (*a*) Name the classes of heavenly bodies that you can see with the naked eye. (*b*) How do you recognize each class? (*c*) Which of these classes belong to the solar system?

2. Planets are often called *stars.* How do planets and stars differ?

3. Name the (*a*) smallest planet, (*b*) the largest, (*c*) the planet that comes nearest the earth, (*d*) the planet most like the earth, and (*e*) the planet with the longest year.

4. (*a*) What planets may pass between the earth and the sun? (*b*) Which planets are larger than the earth?

5. (*a*) Name the planets in the order of their size; (*b*) in the order of their distance from the sun.

6. (*a*) What is the length of the day on Jupiter? (*b*) Jupiter's axis of rotation is nearly perpendicular to its orbit. What effect should this have on its seasons?

7. (*a*) What are planetoids? (*b*) How many are there? (*c*) Where are they located?

8. (*a*) What light makes it possible to photograph the planetoids? (*b*) State two reasons why they are never seen with the naked eye.

9. Compare the diameter of the sun with the diameter of the orbit of the moon.

10. (*a*) How do we know that the sun rotates? (*b*) Compare its period of rotation with that of the earth.

11. (*a*) What are sun spots? (*b*) What apparent effect do sun spots have upon the earth?

12. Account for the light of the sun.

13. What solar phenomena are seen only at the time of a total eclipse of the sun?

14. How does our sun compare in size with the largest stars?

15. Why are certain comets considered members of the solar system?

16. Name two comets so considered and give their periods of revolution.

17. In what respect are comets and stars alike, and in what respect are they different?

18. (*a*) What is a satellite? (*b*) What satellites of other planets may be seen with an opera glass?

19. Explain how the satellites of other planets may be eclipsed.

20. How does the size of our moon compare with that of the satellites of other planets?

21. (*a*) What are *shooting stars?* (*b*) By what name are they properly called?

22. (*a*) What is a meteorite? (*b*) Of what are they usually composed?

23. What is the weight of the largest meteorite known?

24. Certain stars are known to have bodies revolving about them. What does this suggest?

25. (*a*) What is a nebula? (*b*) Describe a spiral nebula. (*c*) How large are the largest nebulæ?

26. What changes now taking place in nebulæ suggest a theory of the origin of planets?

27. State the *nebular* hypothesis.

28. According to the nebular hypothesis, which is older, Jupiter or Mars? Saturn or its moons?

29. State the *planetesimal* hypothesis.

30. According to the planetesimal hypothesis, how is the movement of the satellites about the planets explained?

31. Contrast the nebular and the planetesimal hypotheses as to the origin of the sun, the moon, the ocean, the air.

32. (*a*) How do meteors give us a measure of the depth of the air? (*b*) What makes them become visible?

CHAPTER V

MAP PROJECTION

1. What is a map?

2. (*a*) What does *orthographic* mean? (*b*) In what ways does an orthographic picture agree with this definition? (*c*) Describe the process of orthographic projection.

3. For what kinds of maps is orthographic projection used?

4. Construct an orthographic polar projection of the earth.

5. (*a*) Describe the Mercator projection. (*b*) State its advantages and disadvantages. (*c*) To what part of such a map does the scale apply? (*d*) Why not to all parts?

6. (*a*) Describe the Mollweide projection. (*b*) State its advantages and disadvantages.

7. State the advantages of globes.

8. (*a*) What is meant by the scale of a globe? (*b*) To what part or parts does it apply?

9. Mention several kinds of maps in which true scales can apply only to certain portions.

10. What maps may have scales?

11. (*a*) What are models? (*b*) State their advantages and disadvantages.

12. (*a*) How is relief best represented? (*b*) Describe a hachure map.

13. (*a*) What is a contour line? (*b*) Mention several advantages of a contour map.

14. Define contour interval.

15. On the map of Grass Lake, Figure 37, locate two points, *A* and *B*, either of which could be seen from the other point. Also locate two points not in sight of each other.

CHAPTER VI

PROPERTIES AND FUNCTIONS OF THE AIR

1. Give examples of man's relation to his atmospheric environment: (*a*) With respect to his food, (*b*) with respect to his clothes, (*c*) with respect to his housing.

2. What is the basis of our estimate of more than two hundred miles as the height to which the atmosphere extends?

3. What reason have we to think there is air enmeshed or dissolved in the waters of the earth?

4. What practical uses are made of the properties of compressibility and elasticity of the air?

5. What properties of the air make possible: (*a*) the windmill, (*b*) the balloon, (*c*) the airplane, (*d*) the sailing vessel, and (*e*) the airship?

6. Why may the ordinary type of balloon not be directed in its course?

7. What is meant by the statement that the air is a *mechanical mixture?* Would that mixture be called air if there were no water vapor nor dust in it?

8. Why is there more dust in the air over the land than over the sea, and more water vapor in the air over the sea than over the land?

9. Why are both dust and water vapor more abundant in the lower air than at higher altitudes?

10. (*a*) Why does a balloon rise? (*b*) Why does it sometimes float at a constant level? (*c*) How can it be made to descend? (*d*) How can it be made to rise higher?

11. (*a*) Define *diffusion.* (*b*) What property of the air is due to diffusion?

12. (*a*) Why does carbon dioxide vary at any place, and why is it more abundant at some places than at others? (*b*) When and where is carbon dioxide most abundant?

13. (*a*) What are the chief sources of the dust in the air? (*b*)

Distinguish between organic dust and inorganic dust. (*c*) Which kind do you consider the more objectionable, and why?

14. How is the air naturally cleansed of its dust?

15. Why does not the dust of the air accumulate on the underside of a table to the same extent as on top of the table?

16. (*a*) Why is mountain air purer than the air at lower altitudes? (*b*) Is this the only reason why sanitariums are so frequently located in mountains?

17. Name all the functions of the air as a whole you can recall, arranging them in tabular form.

18. (*a*) Name the various functions of oxygen. (*b*) Why is it necessary for aviators who rise high in the air to carry a supply of oxygen with them?

19. (*a*) Name several substances with which iron is coated to prevent corrosion by the action of the air. (*b*) Why does not the "stainless steel" rust?

20. How does oxygen "purify the air"?

21. Why is oxygen excluded from our electric-light bulbs? *Note.* The first bulbs were vacuum bulbs, but now they are filled with argon or nitrogen to give more stability to the incandescent filaments.

22. (*a*) How do plants make use of the carbon dioxide in the air? (*b*) Under what conditions do plants give out carbon dioxide?

23. If there were more carbon dioxide in the air how would this affect our summers? Our winters? *Note.* It is thought there was a time when carbon dioxide was more abundant in the air than now and that this greater abundance was the cause of glacial climates.

24. Give the round of processes by which carbon dioxide is removed from the air by plants and restored again to the air.

25. Under what conditions will the carbon dioxide be, in part only, restored to the air, the remaining part in the form of carbon being accumulated in the form of coal?

26. (*a*) Trace the processes by which plants get and use the nitrogen of the air. (*b*) Enumerate the common "nitrogen gatherers." (*c*) Is the nitrogen thus gathered usable by other plants besides those which gather it?

27. Since all rainfall comes from the water vapor in the air and the water vapor comes chiefly from evaporation of ocean water, how do the interiors of continents get their rain?

28. Under a thick covering of snow, meadows and wheat fields remain green throughout the winter, though air temperatures fall much below freezing. Why is this?

29. (*a*) What is the relation of the dust in the air to twilight and dawn? (*b*) To our ability to see objects not receiving direct sunlight?

30. (*a*) How are some plants dependent upon the dust in the air? (*b*) How are some diseases related to it? (*c*) How putrefaction and fermentation?

31. (*a*) How is dust related to rainfall? (*b*) How is it related to the color of the sky? (*c*) To the color of the sun at rising and setting?

32. (*a*) According to the nebular hypothesis what is the origin of the air? (*b*) What, according to the planetesimal hypothesis?

33. What is the probable future of the air?

CHAPTER VII

TEMPERATURE OF THE AIR

1. Give six reasons for thinking that the sun is the chief source of our heat.

2. (*a*) How do we know that we receive heat from the interior of the earth? (*b*) If this were the chief source of heat, what part of the earth would be hottest? *Note.* A hot iron ball suspended in air will radiate its heat in every direction until it has the temperature of the surrounding space.

3. Why do we conclude that the interior of the earth is "intensely hot"? Why do we think outer space is "intensely cold"? *Note.* Airplane flights into high altitudes show that the air does not continue indefinitely to grow colder, but a little above seven miles the temperature remains about constant.

4. (*a*) What is *insolation?* (*b*) What part of insolation is transformed into heat? (*c*) What is heat?

5. (*a*) When insolation is received, how is it disposed of? (*b*) Give in tabular form the relative ways in which air, land, and water dispose of insolation.

6. Why is a land area more heated by insolation and more cooled when insolation is withdrawn than a water area alongside?

7. (*a*) Will a house painted red be warmer or cooler in winter than a house painted white? (*b*) Which will be the warmer in summer? (*c*) Why do the inhabitants of hot countries wear light-colored clothing?

8. Why will a kettle of hot water remain hot longer after removal from the fire if the kettle is polished than if the kettle is unpolished?

9. (*a*) Explain the distribution of heat by *conduction,* by *convection,* and by *radiation.* (*b*) Give examples of distributing heat by each process.

10. Why do we heat our kettles from below? Why could we not economically heat them from above? *Note.* Water is heaviest at 39°F., becoming lighter when either heated above or cooled below that temperature.

11. Why do shallow lakes freeze more quickly than deep lakes?

12. The temperature of the deep waters of the Great Lakes is 39° F. Why?

13. Why are heating plants in buildings usually placed at a lower level than the rooms to be heated?

14. Why do we place the heating apparatus in our rooms near the floor instead of near the ceiling, where it would be less in the way?

15. Why does the air warm up faster than it cools down?

16. Why is the lower air more heated and more cooled than the air at higher levels, and why is the air at high levels always cold?

17. Why is the hottest time of the day *after* the hour when insolation is most intense, and the coldest hour near sunrise instead of midnight?

18. Describe the construction of a mercurial thermometer. May the same thermometer be both an F. and a C. thermometer?

19. What makes the mercury rise? What makes it fall?

20. Why should the thermometer tube be of even bore?

21. (*a*) What is the purpose of the bulb of the thermometer? (*b*) If there were no bulb, would the instrument be a thermometer?

22. Many thermometers have a cylindrical instead of a spherical bulb. What is the advantage of one over the other?

23. (*a*) Why are alcohol thermometers necessary in polar regions instead of mercury thermometers? (*b*) Why is mercury better than alcohol in thermometers for high temperatures?

24. Convert the following C. readings to F.: 50°, 40°, 30°, and 10°; the following F. readings to C.: 32°, 50°, and –4.

25. What are maximum and minimum thermometers?

26. (*a*) Describe the maximum thermometer. (*b*) What practical use is made of the maximum thermometer? (*c*) Make a drawing of a maximum thermometer. How is it adjusted for a new reading?

27. (*a*) Describe the minimum thermometer. (*b*) Why is it made with alcohol? (*c*) Why cannot it be hung in a vertical position as an ordinary thermometer? (*d*) How adjust it for a new reading?

28. (*a*) What is a thermograph? (*b*) Does it take the place of the maximum and minimum thermometers? (*c*) From the thermograph record — thermogram — at what time does the maximum temperature usually occur? (*d*) At what time does the minimum temperature occur?

29. How can we get the average temperature for a day? For a week? For a year?

30. (*a*) What is meant by the *temperature range* for a given time? (*b*) From a thermogram find the temperature range for some day.

31. (*a*) Give the chief factors that determine the distribution of insolation over the earth. (*b*) Which of these factors are uniform along a parallel of latitude?

32. What is the relation between the length of the continuous insolation period and latitude (*a*) in the summer hemisphere? (*b*) In the winter hemisphere?

33. (*a*) What is the date of the longest insolation period in the United States? (*b*) What is its date in Australia? (*c*) Give the dates of shortest insolation period in these two countries.

34. (*a*) How does the angle of insolation vary through the day? (*b*) At what hour are we receiving most insolation?

35. (*a*) How does the angle of noon insolation vary at London during the year? (*b*) When is it greatest there?

36. Why is not the angle of insolation the same for all places at any time?

37. (*a*) Why does the angle of noon insolation vary at any place? (*b*) How much does it vary at places outside the tropics?

38. Describe the change in the angle of noon insolation during the year at a place within the tropics.

39. (*a*) What places have vertical insolation once during the year? (*b*) What places have vertical insolation twice? What must be the latitude of a place in order that it may never have vertical insolation?

40. In general how is the *amount* of insolation related to the *angle* of insolation?

41. (*a*) How does the condition of the air as to clouds and dust affect the amount of insolation received? (*b*) Why is more insolation received on a mountain top than in the adjacent valley?

42. Why are oblique rays from the sun less intense than vertical rays? (See page 101.)

43. (*a*) What is the greatest difference in distance from the sun of two places receiving insolation at a given time? (*b*) What is the difference in distance of any place on the earth from the sun at perihelion and at aphelion? (See page 102.)

44. Name factors that affect the distribution of *heat,* but not of *insolation,* over the earth.

45. Make a general statement (*a*) of the relation of the distribution of land and water to the distribution of heat over the earth; (*b*) of the relation of temperature to altitude.

46. How explain the low temperatures of polar regions even during the long summer day?

47. Why is air at altitudes above a few thousand feet always cold?

48. Define "doldrum belt" and "heat equator."

49. Why does the heat equator shift?

50. What determines whether the air is warming up or cooling down?

51. (*a*) Why is the hottest time of day after twelve o'clock? (*b*) The hottest time of the year after the date of the summer solstice?

52. Why does the heat equator shift more over the Atlantic than over the Pacific Ocean?

53. Why is the average position of the heat equator north of the terrestrial equator?

54. (*a*) What are isotherms? (*b*) Why do isotherms have a general east-west trend? Why are they not *due* east-west lines?

55. Why may isotherms *not* intersect? May the heat equator intersect an isotherm?

56. What is meant by *temperature gradient?* (See page 107.)

57. How are the isotherm through any place and the temperature gradient at that place related in direction?

58. (*a*) What is an isothermal chart? (*b*) How are steep and gentle temperature gradients shown on such charts?

59. What instrument gives us a "temperature curve"?

60. (*a*) What is meant by *vertical temperature gradient?* (*b*) What is its average value at low altitudes?

61. Why do we find higher temperatures over Australia, Africa, and South America in January than over the oceans in the same latitude?

62. Why is the winter in the northern hemisphere so much colder than that in the southern hemisphere?

63. Why do the isotherms for January in the northern hemisphere bend southward in crossing the continents, whereas in July they bend northward?

64. (*a*) Why is the temperature of Denver more equable than that of St. Louis? (*b*) Chicago more equable than Minneapolis? (*c*) Atlantic City more equable than Pittsburgh?

65. How can the thermometer be used to determine approximate altitude in a balloon or airplane flight?

66. (*a*) Why do plants put forth their leaves earlier on south slopes than on north slopes of land in the United States? (*b*) Would it be the same in Argentina?

67. Why is a cloudy day in winter warmer and in summer cooler than a clear day?

68. Why is it warmer in summer in St. Louis than at the equator?

CHAPTER VIII

WEIGHT AND DENSITY OF THE AIR

1. Why are we not conscious of the pressure of the air?

2. What is the pressure of the air at sea level, (*a*) per square inch, (*b*) per square foot, (*c*) per acre?

3. How long a column (*a*) of mercury, (*b*) of fresh water, (*c*) of sea water will the air sustain at sea level?

4. How is the sustaining or balancing power of the air used in (*a*) the lifting pump, (*b*) the siphon, (*c*) the barometer?

5. (*a*) What does a cubic foot of air at sea level weigh? (*b*) What weight of air is in your bedroom, (*c*) your classroom?

6. Why does a cubic foot of air weigh more at sea level than at higher altitude?

7. What is meant by the terms *density* and *volume?* What relation exists: (*a*) between *pressure* and *density,* (*b*) between *pressure* and *volume?*

8. How high would we have to ascend to leave half of the weight of the air below us? What part of the air would be below us if we ascended twice as high?

9. (*a*) Define barometer. (*b*) Explain the principle underlying the construction of both the mercurial barometer and the aneroid barometer.

10. (*a*) Give the essential construction of the mercurial barometer. (*b*) Why is it necessary to have some space in the tube above the column of mercury? (*c*) Why is it necessary that this space should be a vacuum?

11. (*a*) What sustains the column of mercury in the tube? (*b*) How long a column of mercury is normally sustained at sea level? (*c*) Why is this column shorter the higher we ascend?

12. In what unit do we ordinarily read the barometer in the United States?

13. (*a*) Why is it necessary to hold the mercurial barometer in a vertical position when taking a reading? (*b*) How rapidly does the barometer fall as we ascend with it above sea level?

14. (*a*) Describe the essential construction of the aneroid barometer. (*b*) What scale besides the one measuring pressures is often found on an aneroid barometer? (See page 118.)

15. Why is the rate of fall of the barometer not uniform as it is carried up in the air?

16. Why does the barometer vary at any place from hour to hour?

17. (*a*) What is a *cyclone* or low? (*b*) An *anticyclone* or high?

18. (*a*) What is an isobar? (*b*) What is pressure gradient? (*c*) What is the relation in direction of the isobar and pressure gradient at any place?

19. In what sense is a *high* an *atmospheric hill,* and a *low* an *atmospheric* basin?

20. How does the spacing between isobars indicate the pressure gradient?

21. Define (*a*) *barograph;* (*b*) *pressure curve,* or barogram.

22. Why are pressures upon the earth in roughly east-west belts?

23. (*a*) Explain the low-pressure *doldrum* belt; (*b*) the high-pressure *horse-latitude* belts. (*c*) Give their approximate latitude positions.

24. Why do the pressure belts shift?

25. How can the barometer be used to determine altitude?

26. Explain why pressure *increases* with increase of temperature in closed vessels filled with air, whereas in the open air pressure *decreases* with increase of temperature.

27. What is meant when we say the pressure of the air is 30 inches?

28. Why is it not necessary to hold an aneroid barometer in any special position?

29. Why is it not necessary that the bore of the barometer tube be uniform as in the thermometer?

30. What is the general relation between barometer change and change in the thermometer?

31. (*a*) Why is mercury so generally used in the construction of liquid barometer? (*b*) Could we have a water barometer?

32. Why do standard barometers have a thermometer attached?

CHAPTER IX

MOVEMENTS OF THE AIR

1. (*a*) Define *wind*. (*b*) Distinguish between winds and currents.

2. (*a*) What is the cause of winds? (*b*) How does the air move *above* a heated area? (*c*) How does the air move about a heated area?

3. Why does a *heated* area become a *low-pressure* area?

4. (*a*) What is meant by *terrestrial winds?* (*b*) Name the belts of winds and calms that constitute the terrestrial winds.

5. (*a*) What and where is the doldrum belt? (*b*) Why is it a low-pressure belt?

6. (*a*) What are the *trade winds,* and why are they so called? (*b*) Between what approximate latitude limits do the trade winds lie?

7. (*a*) What are the *horse latitudes?* (*b*) In about what latitudes are the horse latitudes? (*c*) Why are the horse-latitude belts called *calm* belts?

8. (*a*) Why are the horse latitudes high-pressure belts? (*b*) How does the air move *above* the horse latitudes? (Above does not mean *north* of.)

9. Why do the trades and prevailing westerlies blow *out from* the horse-latitude belts?

10. Why are the doldrums and horse latitudes *belts* rather than *areas?* Why do the winds blow *in toward* the doldrum belt from either side?

11. (*a*) State Ferrel's Law. (*b*) How does this law account for the oblique movement of the trades and prevailing westerlies with reference to the pressure belts?

12. Give the two important laws governing winds.

13. By means of Figure 56 explain deflection of winds from a straight course, or the *pressure gradient.*

14. Since winds moving into regions of either less or greater rotational velocity are deflected from the gradient, where and in what directions could a wind blow upon the earth and *not* suffer deflection?

15. What is meant by the *circumpolar whirls?* Give the direction of this whirl in each hemisphere. (Where winds suffer a deflection to the right and crowd in toward a center, a left-handed or counter-clockwise whirl is developed, and where deflection is to the left a clockwise whirl is developed.)

16. (*a*) Why do the calm and wind belts shift? (*b*) What are *monsoon* winds? (*c*) How many monsoon belts of wind are there? (*d*) Where do they lie?

17. (*a*) Explain the *hooked trades.* (*b*) With what winds do the hooked trades north of the equator alternate? (*c*) With what winds do the hooked trades south of the equator alternate?

18. Of what winds are the hooked trades both north and south of the equator continuations?

19. Why are the monsoons of the Indian ocean the best developed of all on the earth?

20. Why are the circumpolar winds stronger in winter than in summer?

21. Why are the northern Pacific and Atlantic low-pressure areas in winter? (The North Pacific is the region which probably gives rise to our winter cyclones that move southeastward into northwest America.)

22. Since the *continental air drifts* are so easily concealed by the other classes of winds, how is their existence manifested?

23. Why are the *polar areas* thought to be *low-pressure* regions?

24. (*a*) Explain *land* and *sea breezes.* (*b*) About what hour does the sea breeze arrive? (*c*) Why are not land and sea breezes developed every day?

25. (*a*) Explain *mountain* and *valley breezes.* (*b*) When does each blow?

26. The trade winds are *constant* winds and the monsoons are *periodic.* What is the significance of these terms as applied to these winds?

27. What are *cyclonic winds?* Why are cyclonic winds called *unperiodic?*

28. (*a*) Why do highs and lows drift eastward in the United States? (*b*) What direction do they move in Argentina? (*c*) In the trade-wind belts?

29. Using Figures 61 and 62, describe the movement of the winds (*a*) about *highs* in the northern hemisphere and (*b*) about *lows* in the northern hemisphere. (*c*) How would the winds move about highs and lows in the southern hemisphere?

30. What is meant by a *convectional* low? Explain *driven* cyclones and *frictional* cyclones.

31. Name the four distinct movements of the air in and about a low.

32. Give the three customary paths followed by lows in the United States, and tell where those following each path originate.

33. (*a*) Upon what does the *direction* of a wind at any place and time depend? (*b*) Explain a *north* wind. (See page 130.)

34. (*a*) Upon what does the *velocity* of a wind depend? (*b*) Why does the velocity of the wind *increase* as we near the *center* of a *low* and *decrease* as we approach the *center* of a *high?*

35. In what latitudes do cyclonic winds prevail? (See page 130.)

36. (*a*) Define *tornado, hurricane,* and *typhoon.* (*b*) In what particulars do these three storms differ?

37. (*a*) What is the *eye of the storm* in tropical cyclones? (*b*) How do you explain it? (Where the storm is intense and of wide extent the air at the center of the area is *descending.*)

38. (*a*) Why does the wind shift or change in direction at any place? (*b*) Give the direction of shifting when a low passes north of, directly over, and south of a place; also when a high passes in similar fashion.

39. In like manner consider the direction of shifting in the *northwesterlies* of the southern hemisphere.

40. (*a*) About what is the change of temperature with change of *latitude?* (*b*) With change of *altitude?* (*c*) Why does rising air cool, and how fast?

41. (*a*) Why are winds moving poleward *warm winds* and those moving toward the equator *cold winds?* (*b*) Why are rising air currents *warm* and descending currents cold? (*c*) Why does descending air *become warmer?*

42. (*a*) Locate and describe the *hot wave,* the *sirocco,* the *simoom,* the *chinook* and the *foehn.* (*b*) Explain the effect of each.

43. Describe the norther and the blizzard, giving the location of each with characteristics.

44. (*a*) By what instrument is the velocity of the wind measured? (*b*) In what unit is the velocity of the wind measured? (*c*) Give the approximate velocity of a *light breeze,* a *brisk* wind, of a *gale.*

45. (*a*) Why does the wind blow? (*b*) Why is there not always wind?

46. (*a*) Why are summer days, as a rule, more apt to be windy than summer nights? (*b*) Than winter days?

47. Why are trade winds, as a rule, stronger than westerlies?

48. Why are upper currents stronger than surface winds, and winter winds stronger than summer winds?

49. Why are the upper currents in all latitudes from a westerly quarter?

50. Why are storms that come from the southwest often called *northeasters?*

CHAPTER X

MOISTURE OF THE AIR

1. (*a*) What is *water vapor?* (*b*) Define *evaporation.*

2. Upon what does the amount of water in the air chiefly depend?

3. (*a*) At what temperatures does evaporation take place? (*b*) Define *vaporization.*

4. What is it we *see* issuing from a boiling kettle?

5. Define: (*a*) *absolute humidity,* (*b*) *relative humidity,* (*c*) *capacity,* and (*d*) *saturation* as applied to the air.

6. What is meant when it is said the humidity of the air is 60 per cent? 100 per cent? (*b*) What is meant by dew point?

7. (*a*) Define *condensation* as applied to the water vapor of the air. (*b*) Under what condition will condensation take place?

8. How does increase of temperature of the air affect (*a*) evaporation, (*b*) absolute humidity of the air, (*c*) relative humidity of the air?

9. (*a*) Name four ways in which the air may be cooled. (*b*) Which of these occurs chiefly in the day time? (*c*) Which chiefly at night?

10. (*a*) Why does rising air cool? (*b*) At what rate does cooling of rising air go on?

11. Explain the difference between *convectional ascent* and *forced ascent.*

12. (*a*) Why is *descending* air warmed? (*b*) At what rate is it warmed?

13. Explain the abundant rainfall of (*a*) the *doldrums,* (*b*) the *windward* slopes of mountains, (*c*) *low-pressure* areas or cyclones.

14. Explain the deficient rainfall of (*a*) the *horse latitudes,* (*b*) the *trade-wind* belts, (*c*) the *leeward slopes* of mountains, (*d*) *high-pressure* areas or anticyclones.

15. What determines whether the result of condensation of water vapor shall be liquid or solid?

16. Give examples of evaporation of ice without melting.

17. Explain how evaporation is a *cooling process;* that is, that it cools objects in the vicinity of the evaporating substance. In like manner explain how condensation is a *warming process.*

18. (*a*) What is *latent* heat? (*b*) How does it differ from *sensible* heat?

19. Why will a dry bulb thermometer held in front of a rapidly revolving fan show an *increased* temperature and a wet bulb thermometer held in like position show a *decreased* temperature?

20. (*a*) How does fanning cool one's face or hands? (*b*) Why are we so easily chilled in wet garments?

21. (*a*) Describe and explain the principle of the *psychrometer.* (*b*) Under what condition will the wet and dry bulb thermometers show the same reading?

22. (*a*) What does a wide difference in the reading of the wet and dry bulb thermometers indicate? (*b*) What does a small difference indicate?

23. Why is a burn from steam more severe than a burn from boiling water?

24. Explain how exposing pans of water in a room where growing plants are kept may prevent freezing temperatures occurring in the room.

25. (*a*) Why is there more water vapor in the lower air than in the upper air? (*b*) Why more over the sea than over the land? (*c*) How is water vapor distributed in the air?

26. Why does relative humidity usually *increase* with *increase* of *altitude* in the day time, whereas at night it is often greatest at the bottom of the air?

27. (*a*) At what hour of the day or night is relative humidity of the air highest? Why? (*b*) At what hour is it lowest? Why?

28. (*a*) Explain *dew* and *frost.* (*b*) Why do not dew and frost usually occur on cloudy nights? (*c*) Why do they not usually occur on windy nights?

29. Why are station platforms with a roof above them less likely to be covered with frost in winter than those without such shelter?

30. Why is a metal roof more apt to be covered with frost than a wooden or paper roof?

31. (*a*) What are *clouds?* (*b*) Name four types of cloud and tell how they may be recognized.

32. (*a*) How do *cirrus clouds* differ from the other types? (*b*) From which type do rain and snow fall?

33. (*a*) Why are *cumulus* clouds more common in day time than at night? (*b*) Why are they more common over land than over the sea?

34. (*a*) What is fog? (*b*) Why does it occur more often at night or in the early morning than during the day? (*c*) What becomes of fogs?

35. (*a*) What is the explanation of the frequent and dense fogs

over the sea to the east and north of Newfoundland? (*b*) Why are these fogs particularly dangerous to travel and commerce?

36. (*a*) Why is the western coast of the United States more foggy than the eastern coast? (*b*) Account for the frequent and dense fogs of London.

37. Why do fogs gather more frequently and earlier in the evening over lakes and in valleys than on adjacent uplands and mountain slopes?

38. (*a*) Explain *rain* and *snow*. (Much precipitation that *falls* as rain is really melted snow.) (*b*) What is the *snow line?* (*c*) Upon what does the altitude of the snow line depend?

39. (*a*) Explain the formation of *sleet* and *hail*. (*b*) Why is hail usually a summer phenomenon? (*c*) How do you account for the large size of many hailstones?

40. (*a*) Explain *sheet ice*. (*b*) How does sheet ice differ from sleet? (*c*) Explain why sheet ice is destructive to streets and telephone and telegraph lines.

CHAPTER XI

LIGHT AND ELECTRICITY OF THE AIR

1. (*a*) Why does the sun not always appear the same color? (*b*) At what times of the day is it most likely to appear yellow or orange-colored? Why?

2. (*a*) What is light? (*b*) How does it come to us from the sun? (*c*) How fast does it travel?

3. (*a*) How does blue light differ from red as to wave length? (*b*) What effects due to this difference in wave lengths are observed when sunlight passes through dusty air?

4. (*a*) Why is the sky blue? (*b*) Why is it a deeper blue after a rain or snowstorm? (*c*) Why is the sky a deeper blue over the sea than on land? (*d*) On a mountain top than at its base?

5. Why might we expect the stars to appear, even while the sun shines, if we could ascend high enough in the air?

6. (*a*) What is *refraction* as applied to light? (*b*) What two things are necessary to refraction of a ray of light?

7. (*a*) How is a ray of light bent in passing from a rarer to a denser medium? (*b*) From a denser to a rarer medium?

8. (*a*) What is meant by the terms *angle of incidence* and *angle*

of refraction? (*b*) In Figures 76 and 77 indicate these two angles, of *incidence* and *refraction.*

9. (*a*) Why do the sun, moon, and stars seem higher above the horizon than they really are? (*b*) Where would a star have to be situated so as not to be displaced by refraction?

10. (*a*) Why do fish in a clear pool or stream appear nearer the surface than they really are? (*b*) If a rifle were aimed directly at a fish, would the ball hit it?

11. (*a*) What is the effect of refraction of the sun's rays upon the length of the period of sunshine? (*b*) Where is this effect the greatest?

12. (*a*) When viewed from a mountain top, why do other mountain peaks appear higher than they really are? (*b*) As seen from a balloon, why does the landscape below appear bowl-shaped?

13. (*a*) What is looming? (*b*) What are the conditions that make looming possible? (*c*) Why do we not usually see looming at midday? (*d*) Would rising in the air effect the phenomenon of looming?

14. (*a*) What is *total reflection?* (*b*) In Figure 80 indicate the "critical angle." (*c*) What is meant by *critical angle?*

15. (*a*) What are the conditions that make possible the phenomenon of *hot weather mirage?* (*b*) Are both object and reflection visible in this phenomenon?

16. (*a*) What conditions are necessary for *cold weather mirage?* (*b*) What is the position of the reflection in this phenomenon? Is the object necessarily visible?

17. (*a*) What is *dispersion* of *light?* (*b*) What causes the dispersion of the colors?

18. (*a*) Explain halos. (*b*) What is the arrangement of the colors in halo rings? (*c*) Is the phenomenon of colored rings about street lights when seen through foggy air analogous to solar and lunar halos?

19. (*a*) What is the explanation of the rainbow? (*b*) Under what conditions may the rainbow be seen? (*c*) What is the order of the colors in the rainbow? (*d*) Is it the same as in the halo?

20. (*a*) Are the colored rings seen in the spray of a waterfall or a fountain the same phenomenon as the rainbow? (*b*) On which side of a playing fountain should you stand at noon to see the rainbow in the spray? (*c*) Would it be the same in Buenos Aires?

21. (*a*) What is the explanation of the secondary bow? (*b*) What is the order of the colors in this bow?

22. (*a*) In what direction would you see the rainbow in the morning? (*b*) In the evening? (*c*) Why do we so rarely see a rainbow at noon?

23. (*a*) What is lightning? (*b*) What is thunder? (*c*) Why are thunderstorms most common in the afternoon and in summer?

24. (*a*) Why are trees and buildings more apt to be struck by lightning than an animal in the vicinity of the lightning flash? (*b*) Why are lone trees more often struck than trees in a forest?

25. (*a*) What is the principle of the *lightning rod?* (*b*) Why is it necessary that it extend into the ground?

26. (*a*) What is the relation of lightning to rain? (*b*) Why do lightning flashes cease soon after rain begins to fall?

27. (*a*) What is the aurora? (*b*) Is there a similar phenomenon to the aurora borealis in the southern hemisphere? (*c*) Why is the aurora not seen in the tropics?

28. What reason have we for thinking the aurora is electrical in its character?

CHAPTER XII

WEATHER AND CLIMATE

1. (*a*) What is weather? (*b*) What is climate? (*c*) When do you speak of weather, of climate?

2. (*a*) What are the weather *elements?* (*b*) Which do you consider most important, and why?

3. (*a*) How does temperature ordinarily vary through the day and why? (*b*) About what hour of the day is the temperature usually highest? Lowest? Why?

4. (*a*) How does the humidity change with change of temperature? (*b*) At about what hour is humidity highest? Lowest? Why?

5. Why do we not notice changes in the *pressure* of the air, since it is one of the most important weather elements?

6. What are the most important weather *controls?*

7. How are weather changes related to (*a*) altitude, (*b*) distance from the sea, (*c*) latitude?

8. (*a*) Why does the *absolute humidity* ordinarily *increase* during the day, whereas the *relative humidity decreases?* (*b*) Why is relative humidity higher at night?

9. (*a*) Why are *convectional cyclones* more frequent over the land than over the water? (*b*) Why more vigorous in summer than in winter; in day time than at night?

10. Why are *convectional* cyclones more *frequent* and *intense* in *summer,* and nonconvectional cyclones more frequent and intense in winter?

11. Why do cyclones usually continue longer over the sea than over the land?

12. Why, in springtime, do we often have blustery days followed by calm nights?

13. What justification is there for the saying, " Night is the winter of the tropics "?

14. Account for (*a*) the *high temperature,* (*b*) *low pressure,* and (*c*) the *abundant* and *daily rains* of the doldrum belt.

15. Account for (*a*) the *constancy* of the *winds,* both in direction and strength, and (*b*) the *scant rainfall* of the trade-wind belts.

16. Under what conditions do rains occur in the trade-wind belts? Give an example.

17. (*a*) What is the explanation of the *monsoon* changes of weather on the margins of the trade-wind belts? (*b*) Recount these changes.

18. What is meant by the expression " the weather of the prevailing westerlies is of cyclonic control "?

19. Why is there greater regularity in weather changes in the belt of *prevailing northwesterlies* than in that of the *prevailing southwesterlies?*

20. What are the " Roaring Forties " and what is their explanation?

21. How are we able to predict the weather with about 85 per cent verification?

22. Why is weather prediction easier and less important in the doldrum and trade-wind belts than in the belts of the westerlies?

23. For worth-while weather prediction, what controlling conditions must be taken account of?

24. Why do cyclones in the United States move eastward? *Note.* They move generally *southeastward* west of the Mississippi River and *northeastward* east of it.

25. (*a*) Why do the winds about a cyclone center move *toward* that center; and (*b*) why in the *northern hemisphere* do winds spiral about the center *counterclockwise?*

26. Why are the isotherms through a cyclonic area warped into a *northeast-southwest* direction?

27. Why are *temperatures* in *front* of a low *warmer* than in the *rear* of the low?

28. Why does the *cloudy* area and area of *precipitation* extend *farther* in *front* of *than in rear* of the low?

29. What prediction as to (*a*) change of temperature, (*b*) change

in state of sky, and (*c*) change in strength of wind with an approaching low?

30. (*a*) From what direction do lows *approach?* (*b*) What would be the prediction as to weather changes with a *receding* low? (*c*) In what direction do lows recede?

31. Why are passing lows associated with cloudy skies and precipitation?

32. Why do we ordinarily have winds *increasing* in strength as a low *approaches* and *decreasing* in strength as a low *recedes?*

33. (*a*) What is a cold wave, and under what conditions are they apt to occur? (*b*) What is a *blizzard?*

34. (*a*) How do "highs" move across the United States; and (*b*) how do the winds move about a high?

35. Why do *cooler* temperatures *precede* and *warmer* temperatures *follow* the passage of a high across the United States?

36. (*a*) Why are highs usually areas of *clear skies?* (*b*) If clouds appear, why are they apt to be in the *rear* of the high?

37. (*a*) Why do the winds *weaken* upon the approach of a high and *strengthen* as the high recedes? (*b*) from what direction do highs usually approach?

38. (*a*) Why do *thunderstorms* occur in association with *lows* rather than with *highs,* and (*b*) why are they usually southeast of the low center?

39. Why does the lightning in the thunderstorm so quickly cease after the rain begins to fall?

40. (*a*) Why is hail so commonly associated with thunderstorms? (*b*) Why are thunderstorms usually *daytime* and *summer* phenomena?

41. (*a*) What is a *tornado?* How does it differ from a *cyclone?* (*b*) Where in the United States are tornadoes most frequent, and during what months?

42. (*a*) In what direction do tornadoes usually progress in the United States? (*b*) What means are used in western United States to protect from tornadoes?

43. (*a*) How fast do tornadoes ordinarily advance? (*b*) How wide is their path of destruction? (*c*) How strong are the winds sometimes noted about them?

44. Why are tornadoes more frequent in the Mississippi Valley states than in the Rocky Mountain or Appalachian Mountain states?

45. (*a*) What is the *United States Weather Bureau?* (*b*) To what department of the Government does it belong? (*c*) What is its business?

46. (*a*) What weather conditions are shown on the *weather map?* (*b*) How are the data of the weather map got together? (*c*) What instruments are needed?

47. (*a*) At what hour are the observations for the weather map taken? (*b*) Where is the weather map published? (*c*) What purposes does the weather map serve?

48. Why is the weather map of greater importance to the Atlantic than to the Pacific Coast regions?

49. (*a*) Name classes of people benefited by having the weather map, and (*b*) tell in what ways they are benefited.

50. Give the scientific basis of the following weather proverbs: "Rainbow in the morning sailor's warning; rainbow at night sailor's delight." "Mackerel scales and mares' tails, make lofty ships carry low sails." "Mist rising o'er the hill, brings more water to the mill."

51. (*a*) What are the boundaries of the *climatic zones?* (*b*) Why are these boundaries different from the boundaries of the *light zones?*

52. Why is the *north temperate* climatic zone wider than the *south temperate?*

53. Account for the heavy forests and dense jungles of equatorial South American, equatorial Africa, and the East Indies.

54. Account for the desert climate of the Sahara and of central and western Australia.

55. Account for the rainy climate of eastern Australia, southeastern Africa, eastern Brazil.

56. Account for the dry climate of Peru, of the western coast of Mexico, and of Nevada.

57. Account for the bracing climate and light rainfall of the *horse-latitude* belts.

58. Account for the rainy climate of the Pacific Coast of northern United States and Canada and of Chile.

59. (*a*) Why are low-lying land areas in the trade-wind belts likely to be desert? (*b*) Why are the southern coasts of the mountainous islands of the West Indian and Hawaiian groups of islands dry?

60. Account for the rainy climate of the eastern slopes of the Sierra Madre Mountains of Mexico and of the eastern Andes slopes of Peru.

61. Explain the monsoon character of the climate of India.

62. (*a*) Why are the western coasts in the belts of westerlies more uniform in climate than the eastern coasts? (*b*) Why are the eastern coasts more uniform than the interiors?

63. (*a*) In what way does the Gulf Stream influence the climate of the coasts it washes, and (*b*) what coasts are affected by this stream?

64. Explain the climatic influence of (*a*) the Japan Current, (*b*) the Chilean Current, (*c*) the Labrador Current. (See *Ocean Currents.*)

65. (*a*) What are the *Polar Cold Caps?* (*b*) What are their chief climatic characteristics? (*c*) Why is the Antarctic cap larger than the Arctic?

66. (*a*) What is meant by *continental* and *marine* climates? (*b*) Why are marine climates less variable than continental?

67. (*a*) What are the distinguishing characteristics of *mountain climates?* (*b*) What is the chief difference in *climates* on *windward* and *leeward* sides of mountains?

68. (*a*) Why do continent interiors have their greatest amount of rainfall in summer? (*b*) Why does the western coast in the westerlies have more rainfall in winter than in summer?

CHAPTER XIII

CLIMATE OF THE UNITED STATES

1. The two outstanding climatic characteristics of the Pacific Coast of the United States are *equable temperature* and *winter rains.* Explain.

2. (*a*) Why is the Great Basin of western United States dry? (*b*) What is the source of the small amount of rain it receives? (*c*) Explain its extremes of temperature.

3. The 100th meridian west marks approximately the boundary line between *profitable* and *unprofitable* agriculture by ordinary methods. Explain.

4. (*a*) Why are the lands between the Rocky Mountains and the Mississippi River so largely prairie? (*b*) What are the chief agricultural products of these prairies?

5. Account for the increasing rainfall eastward from the Mississippi River to the Appalachian Mountains and the heavy snowfall of the Great Lakes region.

6. (*a*) Why is the Atlantic Coast of the United States more varied in climate than the Pacific Coast? (*b*) What two ocean currents affect this coast? (See *Ocean Currents.*)

7. (*a*) Describe the course of tropical cyclones originating in the West Indies. (*b*) At what season of the year are they most frequent?

8. Why does Boston have a greater number of cyclonic disturbances than any other city of its size in the United States?

9. Name three cities with distinctly *winter* rains, three with distinctly *summer* rains, and three with rain distributed pretty uniformly through the year.

10. Locate and explain the *greatest* rainfall and the *least* rainfall in the United States.

11. (*a*) From what direction do storms in your section usually come? (*b*) What direction of wind is most apt to bring snow in winter and rain in summer?

12. (*a*) What direction of wind is usually coldest? (*b*) Warmest? (*c*) Most apt to be accompanied by fog?

CHAPTER XIV

GENERAL CHARACTERISTICS OF THE SEA

1. What important advantages to cities arise from location near the sea?

2. Distinguish between sea, ocean, and lake. (See page 443.)

3. What effect do continental and mountain masses have upon the level of the sea along their borders? Give examples.

4. Compare the areas and the lengths of shorelines of the Atlantic and Pacific Oceans.

5. Describe conditions about the south pole that make it less accessible than the north pole.

6. Where and what is the greatest known depth of the sea?

7. (*a*) What is the average depth of the sea? (*b*) The average altitude of the land?

8. If all the land above sea level were carried into the sea, would there be enough of it to fill the ocean basins?

9. How many pounds of common salt are there in a hundred pounds of sea water?

10. (*a*) How do the gases, oxygen and carbon dioxide, get into sea water? (*b*) What use is made of them?

11. (*a*) Why are not all parts of the sea equally salty? (*b*) Where is sea water most salty? (*c*) Where least?

12. Account for the low temperature of deep ocean waters.

13. What economic and what scientific information has been obtained by sounding and dredging?

14. Why is the ocean floor in general smoother than the surface of the land?

15. How do you account for islands in the ocean near continents? In mid-ocean?

16. (*a*) What is the continental shelf? (*b*) Compare its widths along the eastern and western coasts of the United States.

17. Compare the deposits of the continental shelf with the oozes beyond its limits.

18. (*a*) State the sources of the deposits in the "deeps" of the ocean. (*b*) What evidence have we that these deposits accumulate very slowly?

19. (*a*) What is the difference in origin of an *iceberg* and an *ice floe?* (*b*) Where do the icebergs of the North Atlantic come from? (*c*) In what ways are they a menace to ships?

20. State reasons for the greater abundance of life on the continental shelf than in mid-ocean.

21. Consult Figure 102, and account for the more southerly and easterly of the limit of drifting ice in the northern hemisphere in summer.

CHAPTER XV

MOVEMENTS OF THE SEA

1. (*a*) A wave has been defined as a hill of water that comes toward you. What can you say in favor of this definition? (*b*) What can be said against it?

2. Name the most important motions of ocean water, and state the cause of each.

3. How does the direction of motion of the wave compare with the direction of the wind?

4. If we were to dye a certain wave red as it passed our boat, should we be able to identify the wave when it passed the boat that was following us? Explain.

5. (*a*) When swimming beyond the breakers, are you carried forward with the first wave that you meet? (*b*) In other words could you ride a wave to shore?

6. Distinguish between the motion of a wave and the motion of the particles of water that form the wave.

7. Define *crest, trough, height* of wave, *length* of wave, *ground swell, breaker, surf,* and *undertow.*

8. Why does the front of a wave become steeper as it approaches the shore?

9. In what two ways do waves wear away a sea cliff?

10. (*a*) How are sea caves formed? (*b*) How are beaches formed?

11. Describe the formation of a sand reef, a sand spit, and a "hook."

12. Define tides, *flood tide, ebb tide, tidal range, tidal race, bore.*

13. (*a*) What are spring tides? (*b*) Neap tides? (*c*) Why are both spring and neap tides more pronounced in the northern hemisphere during its winter than during its summer?

14. Why is the tidal range greater in some harbors than on the open sea?

15. What is the interval between two successive high tides?

16. What number of minutes is called the moon's "ear mark" on the tides?

17. (*a*) What is meant by the *running of the tide?* (*b*) Why does the tide run in different directions at different times?

18. What is meant by the *establishment of a port?* Why is this quantity important?

19. State the economic importance of tides.

20. (*a*) What provisions are made for docking ships in harbors with considerable tidal range? (*b*) Why does the tidal range vary from day to day?

21. (*a*) The moon is considered the chief cause of the tides. (*b*) With our moon going around the earth in about four weeks, how is it that we have two daily high tides?

22. When is a boat more likely to run aground during the low water of a spring tide or the low water of a neap tide? Explain.

23. (*a*) What is meant by *tidal scour?* (*b*) What effect has this upon inlets?

24. There are several important ocean currents in each of the oceans. Name some of them and specify whether warm or cold currents.

25. Explain why the birthplace of ocean currents is located in the trade-wind belts.

26. Why do the westward equatorial currents turn northward or southward?

27. How are the low temperatures of the deep equatorial seas accounted for?

28. Why does the ocean current that *warms* British Columbia *cool* the coast of Mexico?

29. What effects of the Gulf Stream are of great importance to many persons?

30. Explain the semiannual reversal of the direction of the eddy in the North Indian Ocean.

31. Why is the temperature of northern Norway so much warmer than that of Alaska in the same latitude?

32. Account for the (*a*) bleakness of Kamchatka and Labrador, the (*b*) fogs off Newfoundland, and (*c*) the coral rock of the Bermudas.

33. Why does a portion of the South Equatorial Current cross the equator and join the Gulf Stream?

34. Why do ships sailing from Honolulu to San Francisco take a more northerly route?

35. Why do sailing vessels leaving New York for Rio Janeiro go so far over toward the African coast before crossing the equator?

36. What route should you advise them to take on their return trip?

CHAPTER XVI

THE MANTLE ROCK

1. Define *rock, mantle rock,* and *bedrock.* Give an example of each.

2. What are the chief functions of the mantle rock?

3. Name several kinds of mantle rock, and state their economic uses.

4. Define weathering.

5. Make a list of all the mechanical agents of weathering, and another of the chemical agents.

6. Explain the difference between mechanical and chemical weathering.

7. Under what climatic conditions is freezing and thawing most effective?

8. (*a*) How does moisture aid weathering? (*b*) Wind-driven sand? (*c*) The oxygen of the air? (*d*) Change of temperature? (*e*) Gravity? (*f*) The carbon dioxide of the air?

9. How does mantle rock retard weathering below the surface?

10. Name several agents that transport mantle rock.

11. Mention some mass of transported mantle rock, and name the agent that transported it.

12. Under what conditions does gravity transport mantle rock?

13. (*a*) Describe the transportation of mantle rock by wind; (*b*) by waves.

14. Name several characteristics of alluvial mantle rock.

15. Name a common form in which æolian mantle rock is found.

16. State the characteristics of glacial mantle rock.

17. State and account for the differences between transported and residual mantle rock.

18. Explain the origin of peat, and name a region where it is used as fuel.

19. (*a*) How are sand dunes formed? (*b*) By diagram, show the leeward and the windward slopes of a sand dune.

20. What means are sometimes used to check their forward movement?

21. Name localities where sand dunes may be found.

22. Briefly describe the method by which each of the following was formed: marl, humus, muck, silt, loess.

23. (*a*) Define soil. (*b*) Compare the characteristics of clay soils with those of loam; (*c*) with those of sandy soils.

24. (*a*) Why are soils "earlier," or more responsive, on south-facing than on north-facing slopes; (*b*) when well-drained than when poorly drained?

25. What other conditions affect the earliness of soils?

26. To what dangers of loss or deterioration is soil exposed?

27. Mention measures that may be taken to conserve soil and to maintain its fertility.

CHAPTER XVII

THE BEDROCK

1. Define mineral and explain the difference between minerals and rocks.

2. Name four properties that aid in distinguishing minerals.

3. Name four rock-making minerals, giving the principal distinguishing characteristics of each.

4. Give the essential composition of (*a*) granite, (*b*) sandstone, (*c*) shale, (*d*) mica schist, (*e*) slate, (*f*) limestone.

5. (*a*) Name three classes of rocks, based upon their origin. (*b*) Give an example of each class.

6. In what parts of the United States are the bedrocks chiefly of

(*a*) igneous origin, (*b*) of metamorphic origin, (*c*) of sedimentary origin?

7. Give a theory as to rock salt deposits, and mention several localities where rock salt may be found.

8. Arrange in tabular form the several kinds of rock waste being deposited upon the ocean floor, with the bedrock derived from each, and with its metamorphic equivalent.

9. (*a*) What metals occur in the rocks in their pure state? (*b*) By what name are these metals known?

10. Name five important minerals used in the arts.

11. Define ore, and give the name of an ore of each of the following metals: *iron, copper, lead, zinc, tin,* and *mercury.*

12. By what characteristic features may each of the following be identified: (*a*) conglomerate, (*b*) shale, (*c*) limestone, (*d*) granite, (*e*) sandstone.

13. Classify the following rocks as to origin: (*a*) sandstone, (*b*) marble, (*c*) anthracite coal, (*d*) limestone, (*e*) basalt, (*f*) pumice, (*g*) granite, (*h*) clay, (*i*) shale, (*j*) obsidian, (*k*) lava.

14. (*a*) What is the significance of stratification in rocks? (*b*) How does this property aid in quarrying rocks?

15. How are the cleavage planes in slate produced?

16. Why is the rock waste brought to the ocean assorted, and the different sized particles deposited in different places?

CHAPTER XVIII

STORIES IN STONE

1. What is meant by "stories in stone"?

2. (*a*) What are fossils? (*b*) Account for their occurrence in sedimentary rocks.

3. How does the series of sedimentary rocks tell us the relative times when the different forms of life inhabited the earth?

4. What sort of changes were used to divide the rock record into eras?

5. What is the earliest form of plant life thus far found?

6. What forms of life existed when the proterozoic rocks were being formed?

7. What great change is shown in the life of the earth at the beginning of the paleozoic era?

8. What was the highest type of life at the beginning of the paleozoic era?

9. What was the highest type in the middle of the paleozoic era?

10. Describe the development of the eyes of the trilobites during the paleozoic era.

11. What two forms of animal life appeared in the latter part of the paleozoic era?

12. What conditions prevailed during the coal-forming period?

13. Mention several events that tended to destroy much of the animal life at the close of the paleozoic era.

14. (*a*) When did birds first appear? (*b*) What peculiar characteristics had they?

15. Describe one of the great reptiles of the mesozoic era.

16. (*a*) When did mammals appear? (*b*) Describe one of the early mammals.

17. In what era did man appear?

18. Show by diagram the order in which the different classes of life appeared upon the earth as indicated by fossils.

CHAPTER XIX

THE GROUND WATER

1. What becomes of the rain?

2. What conditions control the percentage of rain water evaporated?

3. How does evaporation affect the temperature of the air?

4. Mention three factors that determine the percentage of the rainfall that sinks into the ground and becomes ground water.

5. Define *ground water, run-off, water table, water vapor, adhesion water, impermeable rock.*

6. Why is the water table sometimes horizontal and sometimes inclined?

7. What controls the direction of flow of the ground water? What force causes this motion?

8. What action keeps the soil moist above the water table?

9. How far down does the ground water extend?

10. Name at least five ways in which the ground water returns to the surface.

11. Classify the kinds of work performed by ground water as constructive and destructive work.

12. What conditions make erosion by ground water possible?

13. What two substances found in bedrock are readily soluble in water?

14. Name five deposits formed by ground water and five materials deposited by it.

15. (*a*) Why are certain minerals deposited about springs? (*b*) About geysers?

16. How are caves formed?

17. Draw a diagram of a cave showing a sinkhole, stalactite, stalagmite, and a pillar.

18. Why are most caves formed in limestone regions?

19. (*a*) Describe the forms of life in the Mammoth Cave. (*b*) How do they illustrate the adaptation of animals to their environment?

20. How are some natural bridges formed?

21. (*a*) What is calcareous tufa? (*b*) How is it formed?

22. Name four results of solution and deposition by ground water.

23. Draw a diagram, and explain why some wells are permanent and others temporary.

24. State the relation between the level of the water table near a well and the level of the water in the well.

25. Name some of the sources of contamination of wells.

26. (*a*) Describe the sanitary location of a well. (*b*) State two general laws governing the sanitation of wells.

27. (*a*) What is an artesian well? (*b*) Why is its water usually of exceptional purity?

28. Explain why the water of an artesian well rises sometimes above the level of the local water table.

29. How was the "captive sheet" captured?

30. (*a*) What is a spring? (*b*) A mineral spring? (*c*) A geyser?

31. Name regions famous for their springs.

32. (*a*) What conditions determine the volume of springs? (*b*) Their permanence? (*c*) Their location?

33. (*a*) Locate several hot springs. (*b*) What substance is sometimes deposited by them?

34. What is a quicksand?

35. (*a*) How is the water of a geyser heated? (*b*) Why is the eruption not continuous?

36. Name three regions where geysers exist.

37. Explain the action of a geyser.

38. What substance is deposited about a geyser?

39. (*a*) What is formed when the water table is above the surface? (*b*) When it is at, or slightly below, the surface? (*c*) When it is too low?

40. (*a*) What is irrigation? (*b*) Dry-farming? (*c*) Describe the processes used in dry-farming.

CHAPTER XX

RIVERS

1. Of what importance are rivers as highways?

2. (*a*) How does the Mississippi illustrate the importance of river transportation to commerce? (*b*) The Great Lakes?

3. How does the use of rivers for transportation in Europe compare with their use in this country?

4. State the advantages and the disadvantages of rivers as sources of water supply for cities.

5. (*a*) What military advantage does a river offer in time of war? (*b*) Name rivers that were important during the World War; (*c*) during our Civil War.

6. Why are rivers unsatisfactory as national boundaries?

7. From what sources do rivers obtain water?

8. Define *river, tributary, river system, river basin, river valley, divide.*

9. Locate the following parts of a stream: (*a*) source, (*b*) mouth, (*c*) bed, (*d*) bank, (*e*) channel.

10. Is the drainage of land afforded by streams an advantage or a disadvantage?

11. State facts concerning the great flood in the Mississippi Valley in 1927.

12. Briefly describe three methods of controlling floods.

13. Summarize the life work of rivers.

14. Define *corrasion,* or stream erosion.

15. Distinguish between the destructive and the constructive work of rivers.

16. (*a*) What is a gully? (*b*) Explain how the formation of gullies on farms may be checked.

17. Name four features due to erosion of bed.

18. Name and define two processes by which streams loosen and remove particles of mantle and bedrock.

19. In what four ways do streams transport rock waste?

20. (*a*) In which of these ways does the Mississippi transport the largest amount? (*b*) The smallest?

21. Define *comminution.*

22. Using a diagram, explain how moving water can hold particles heavier than water in suspension.

23. Under what conditions does a stream form a canyon?

24. By what action is a canyon transformed into a V-shaped valley?

25. Explain how erosion of bed sometimes makes rivers longer.

26. Using a diagram, explain stream piracy.

27. Name three features due to differential erosion.

28. How are river valleys widened?

29. Explain the meandering of rivers as they grow older.

30. (*a*) Describe an undercut bank. (*b*) How is a cut-off formed?

31. Name four features due to erosion of bank.

32. Upon what conditions does the rate of erosion by a river depend?

33. (*a*) What are rapids? (*b*) How are rapids formed?

34. (*a*) What are falls? (*b*) Describe at least two ways in which waterfalls are formed.

35. Name the cities along the fall line in southeastern United States.

36. (*a*) Show by diagram how certain falls retreat upstream. (*b*) Where will a fall disappear?

37. (*a*) What are water gaps? (*b*) How are they formed?

38. Describe the assorting action of a stream.

39. How are stratified deposits formed by streams?

40. Describe the formation of a sand bar.

41. What is an overloaded stream?

42. (*a*) Draw a cross-section of a flood plain, and describe its formation. (*b*) Why is it highest near the river?

43. What is an alluvial fan?

44. (*a*) What is a river profile? (*b*) Sketch a profile that is convex to the sky; (*c*) one that is concave to the sky.

45. (*a*) What is the base level of erosion? (*b*) The profile of equilibrium?

46. (*a*) State the characteristics of a young river. (*b*) Give an example.

47. (*a*) State the characteristics of a mature river. (*b*) Give an example.

48. (*a*) State the characteristics of an old river. (*b*) Give an example.

49. In which stage of development is a river best adapted to the demands of commerce?

50. In which stage of its development is the river valley most favorable to agriculture?

51. (*a*) How are deltas formed? (*b*) What are natural levees?

52. In what ways may the normal cycle of a river's development be interrupted?

53. State the result of each change mentioned.

54. Name features produced by the depression of a river at its mouth.

55. (*a*) What is a dismembered stream? (*b*) What is a drowned valley? (*c*) An estuary?

56. How does the elevation of a river basin at its source affect the length of its cycle?

57. (*a*) What are rejuvenated streams? (*b*) Entrenched meanders? (*c*) Engrafted streams? (*d*) Alluvial terraces?

58. What are the chief functions of lakes?

59. Mention several ways in which lake basins have been formed, illustrating each.

60. What kinds of lake basins are made by the streams themselves?

61. Describe the stages in the formation of an oxbow lake.

62. (*a*) Name the largest lake, (*b*) the highest lake, (*c*) two that are below sea level, (*d*) the deepest lake, and (*e*) the one that varies most in size.

63. Mention three ways in which lakes may be destroyed.

64. How did the fresh water Lake Bonneville become Great Salt Lake?

65. State the economic importance of lakes.

CHAPTER XXI

GLACIERS

1. (*a*) What is a glacier? (*b*) Where are glaciers found? (*c*) What determines whether or not glaciers shall occur in any region?

2. (*a*) What is the *snow line?* (*b*) How is the height of the snow line related to latitude? (*c*) What is the altitude of the snow line at the equator?

3. Distinguish between *alpine* and *continental* glaciers, and give locations of each type.

4. (*a*) What determines the position of the *ice front* of the glacier? (*b*) Under what conditions will the front of a valley glacier *advance; retreat?*

5. (*a*) What is the explanation of the *subglacial stream?* (*b*) Why is it usually milky in color? (*c*) Why does the subglacial stream clear in passing through a lake?

6. (*a*) Give the geographic distribution of glaciers. (*b*) Where in the United States and its possessions may glaciers be found? (*c*) Where is Glacier National Park?

7. (*a*) Why do we find *continental* glaciers only in the polar regions? (*b*) Why is there no glacier at the North Pole? (*c*) What is the nature of the ice there?

8. (*a*) What is *névé?* (*b*) Why does the glacier move? (*c*) *How* does it move, and at about what rate do the Swiss glaciers move? (*d*) What is regelation?

9. Compare and contrast the valley glaciers or *ice* rivers with rivers of water.

10. Why do glaciers move faster in the center than at the sides, and faster at the top than at the bottom?

11. (*a*) Explain crevasses: lateral, longitudinal, transverse. (*b*) Explain *glacial mills* and *potholes.* (*c*) How are they related to crevasses?

12. (*a*) Describe the kinds of work glaciers do. (*b*) What are *roches moutonnés?* (*c*) Explain *glacial striæ* and *glacial grooves.*

13. (*a*) Explain the origin of *U-shaped* valleys. (*b*) What are *cirques,* and how are they formed? (*c*) Name two ways continental glaciers level the land.

14. (*a*) Explain *moraines:* medial, lateral, terminal, ground. (*b*) Is the load carried by a glacier related to its velocity of motion as in rivers?

15. (*a*) What are *glacial tables?* (*b*) Why do they fall from their ice pedestal usually in a southwest direction in the northern hemisphere? (*c*) In what direction do they fall in the southern hemisphere?

16. How do the materials in the moraines differ in appearance from those of deposits made by rivers? Why?

17. How do deposits made by glaciers differ from those made by rivers? Why?

18. (*a*) What is *stratified drift?* (*b*) Where and how was it made? (*c*) By what names is it known?

19. (*a*) Explain the origin of: kames, eskers, drumlins. (*b*) Where

in New York State can examples of each of these deposits be found?

20. How can we know that present Swiss glaciers were once much more extensive?

21. (*a*) What is meant by " the ice age in North America " ? (*b*) Are there such conditions anywhere at the present to merit the term *ice age?*

22. What are some of the evidences to be found that such conditions as suggested by the term *ice age* ever existed in the United States?

23. (*a*) Where were the centers of accumulation of the ice constituting the continental glacier of this glacial period? (*b*) How far south did the glacial ice sheet reach?

24. (*a*) What were some of the effects of this invasion of ice from the north, to be observed now? (*b*) Why did it not reach farther south? (*c*) How does the topography of the ice invaded region differ from that not invaded?

25. (*a*) Trace the southern limit reached by the ice sheet across the United States. (*b*) How is this limit recognizable?

26. (*a*) Why is the topography of the glaciated region in the United States so much younger than that of the unglaciated? (*b*) What difference in the rivers of the two regions?

27. What is the explanation of the numerous stone walls seen in New England and other glaciated regions, and their absence in Virginia and other regions south of the *terminal moraine?*

28. The glaciated section of the United States is characterized by numerous lakes. Explain three ways by which the glacial ice sheet was responsible for these lakes.

29. Explain the series of parallel morainic ridges in Indiana and Ohio southwest of Toledo as shown in Figure 265.

30. (*a*) How do the glacial soils north of the Ohio River differ from the residual soils south of that river? (*b*) Are glacial soils necessarily better or poorer than residual soils?

31. (*a*) What occasioned the *glacial period?* (*b*) Why did the ice sheet disappear? (*c*) Is it possible that we may have another glacial period in the United States?

32. (*a*) What is the *drift* of the glacial period? (*b*) What is *till?* (*c*) What is the origin of the *loess?* (*d*) What reason have we to think the loess was deposited in the nature of *natural levees* along the banks of glacial rivers?

33. What was the origin of the Finger Lakes of New York; of the Great Lakes along the northern border of the United States?

34. (*a*) Explain Lakes Duluth, Chicago, and Maumee, and their outlets southward. (*b*) When were these southward outlets abandoned?

35. (*a*) Explain glacial Lake Agassiz. (*b*) Where was its outlet? (*c*) Why did it disappear? (*d*) For what is its bed now used? (*e*) What were Lakes Algonquin and Iroquois?

36. How does the Niagara gorge serve as a measure of postglacial time?

37. Explain the economic relation of the *drift* to (*a*) stream flow, (*b*) building of roads and railroads, (*c*) agriculture, (*d*) water power, and (*e*) mining.

38. Explain the "hanging valleys" of the Finger Lakes region in New York.

39. Give three explanations of the cause of the glacial period.

CHAPTER XXII

PLAINS

1. (*a*) Define *relief*. (*b*) What is the extreme relief of the earth?

2. Name the important relief features of the land.

3. How does the relief of a region influence the occupations of the inhabitants?

4. (*a*) Define *plain*. (*b*) State the economic importance of plains.

5. Mention four types of plains formed by deposition.

6. Give the reason for the nearly level surface of each of the types.

7. Name the materials that form a marine plain, and describe its structure.

8. Why are artesian wells numerous on coastal plains?

9. Describe the soil of a coastal plain.

10. State the location and the extent of the Atlantic Coastal Plain.

11. (*a*) Give proof of its marine origin. (*b*) Name the products of this plain.

12. (*a*) Locate an ancient coastal plain. (*b*) How can an ancient coastal plain be recognized?

13. Mention several evidences of change in the relative level of the land and the sea.

14. (*a*) State the origin of lacustrine plains. (*b*) What is the nature of lacustrine deposits?

15. State the conditions that led to the formation of the lacustrine plain in the valley of the Red River of the North.

16. Describe the floor of former Lake Bonneville. (See page 495, and Figure 273.)

17. Locate several other lacustrine plains.

18. Why did Lake Bonneville disappear? (See page 455.)

19. State the economic importance of lacustrine plains.

20. (*a*) What is a *playa?* (*b*) A *salina?* (*c*) Locate a salina in the United States, and one in South America.

21. Describe the flood plain of the Mississippi River. Name several other rivers having important flood plains.

22. State the advantages, disadvantages, and dangers of life on flood plains.

23. How may these disadvantages be overcome?

24. Name two flood plains of historical importance.

25. Mention two types of glacial plains, and locate an example of each.

26. How was each type formed?

27. Describe the structure of the deposit forming each type.

28. What are piedmont alluvial plains?

29. (*a*) What are erosion plains? (*b*) By what other name are they known?

30. How may erosion plains be distinguished from plains of deposition? (See page 500.)

31. What is a monadnock? Locate one.

32. What does Figure 278, of Jail Rock, Nebraska, show?

33. How were the Great Plains formed?

34. Describe the variation in the deposits of the Great Plains.

35. Explain the origin of the following areas of nearly level land: (*a*) The Red River Valley in Minnesota and Manitoba. (*b*) The eastern part of Virginia, North Carolina, and South Carolina, (*c*) Louisiana, (*d*) central California, (*e*) northern Siberia, (*f*) northern Egypt.

36. Why are some plains deserts?

37. What is the cause of the desert about the head of the Gulf of California? (See page 201.)

38. Name and locate two trade wind deserts, one of which lies in the rain shadow of a mountain. (See page 187.)

CHAPTER XXIII

PLATEAUS AND MOUNTAINS

1. (*a*) Define *plateau.* (*b*) Mention three ways in which plateaus have been formed.

2. (*a*) What is a fault? (*b*) Draw a diagram of a fault and point out the "throw" of the fault.

3. (*a*) What is the fault line (trace)? (*b*) The fault plane?

4. (*a*) Describe a fault plateau. (*b*) Locate one.

5. Sketch a fault plateau showing its rock structure.

6. Compare the erosion of plateaus with that of plains.

7. What striking features are developed by erosion of young plateaus?

8. (*a*) Describe a mature plateau. (*b*) Has it a level upland surface? (*c*) How do we know that it ever was a plateau?

9. Locate and state the characteristics of the Appalachian Plateau.

10. Sketch a cross-section of the Appalachian Plateau. (See Figure 285.)

11. What are the industries of the Appalachian Plateau?

12. (*a*) Describe an old plateau. (*b*) Define *mesa; butte.*

13. Compare the economic importance of a high plateau in the tropics with that of a similar plateau in the temperate zone.

14. (*a*) By what means may certain plateaus in arid regions be made fertile? (*b*) What situation favors this? (See page 285.)

15. Define *mountain peak, ridge, range, chain, cordillera.*

16. Give an example of a mountain chain; of a cordillera.

17. (*a*) Describe the formation of a domed mountain, using a diagram. (*b*) Give an example.

18. (*a*) Draw a diagram of fault mountains. (*b*) Explain how they were formed and give two examples.

19. Show by diagram the structure of simple folded mountains, and name several examples.

20. What is known about the forces that formed folded mountains?

21. Define *anticline* and *syncline,* and draw a diagram of each.

22. (*a*) Show by a diagram of several synclines and anticlines how we know that the Appalachian Mountains were once much higher than they now are. (*b*) Reconstruct the folds.

23. Enumerate five types of mountains, giving an example of each.

24. (*a*) Why are there no trees on the tops of high mountains? (*b*) Define *timber line.* (*c*) What is its altitude in the Rockies?

25. State four facts about the mountain-building forces.

26. (*a*) Sketch the structure of the Rocky Mountains. (*b*) How do we know that the Rocky Mountains are younger than the Appalachians?

27. State three facts about the erosion of mountains.

28. Explain why mountains are eroded more rapidly than plains.

29. (*a*) What is meant by the "period of growth" of a mountain? (*b*) The "period of decline"?

30. Define cycle of erosion of a land form.

31. How may a cycle of erosion be interrupted?

32. Upon what relation does the height of a mountain at any given time depend?

33. (*a*) State the characteristics of a young mountain. (*b*) Give example.

34. (*a*) State the characteristics of a mature mountain. (*b*) Give example.

35. (*a*) State the characteristics of an old mountain. (*b*) Give example.

36. Compare the climatic effect of changing altitude on a mountain with the effect of changing latitude without changing level. (Recall the vertical temperature gradient and the horizontal temperature gradient.)

37. (*a*) How does the location of a mountain range with respect to prevailing winds, cause differences in the climates of the windward and leeward sides of the range? (*b*) Give at least three illustrations.

38. Why are mountains nearly always sparsely settled?

39. Show how mountain environment has influenced history, especially during wars.

40. How does the isolation of mountain regions affect the language, the customs, and the progress of the inhabitants.

41. (*a*) Explain in detail the retarding influence on exploration and settlement of a long mountain range. (*b*) Give example.

42. Mention several physical features of eastern United States that made New York City the metropolis of the country.

43. (*a*) State several reasons why mining has become an important industry in mountain regions. (*b*) Give examples.

44. State two reasons why water power is more easily obtained in mountain regions than on plains. (Recall the equivalent of one horse power.)

45. Contrast agriculture on mountains with agriculture in valleys.
46. What conditions in mountain regions make irrigation of near-by lands possible?
47. Why is the western slope of the Sierra Nevada Range forest covered, whereas the eastern slope resembles the Great Basin in barrenness?
48. What are the reasons for maintaining large forest reserves?
49. By means of a diagram, show how a syncline may become a hill.

CHAPTER XXIV

VOLCANOES AND EARTHQUAKES

1. Define *volcano, crater, cone, lava, ash, bomb.*
2. How are volcanic cones formed?
3. Upon what does the steepness of the cones depend?
4. State three theories as to the origin of the heat that forms lava.
5. From what source is the energy of an explosive eruption derived?
6. Where does the water that accompanies an explosive eruption come from?
7. Account for the increasing pressure noted in explosive eruptions.
8. (*a*) Describe an ordinary explosive eruption. (*b*) What damage does it do? (*c*) What often follows it? (*d*) What sometimes precedes it?
9. What conditions permit oozing eruptions?
10. (*a*) Describe an oozing eruption. (*b*) What damage does it do?
11. (*a*) Describe a young volcanic cone. (*b*) Mention two examples.
12. (*a*) Describe a mature cone. (*b*) Give an example.
13. (*a*) Describe an old cone. (*b*) Name three kinds.
14. (*a*) Describe a volcanic neck. (*b*) Locate one.
15. Describe the caldera of Crater Lake; of Mauna Loa.
16. Describe the columnar structure of certain cooled lavas.
17. State the distribution of volcanoes.
18. Why are they so frequently located among young mountains?
19. Name four gaseous products of an explosive eruption.

20. (*a*) What substances are erupted in a liquid state? (*b*) In a solid state?

21. (*a*) What products of an eruption retain their gaseous state on cooling to ordinary temperatures? (*b*) Their liquid state?

22. Recall descriptions of obsidian, basalt, granite, pumice, felsites.

23. Mention four volcanic products that have economic value, and name a locality where each may be found.

24. How do the eruptions of Vesuvius differ from those of Stromboli?

25. (*a*) What is a dormant volcano? (*b*) An extinct volcano?

26. Name and locate several extinct volcanoes in the United States.

27. (*a*) What is the character of the eruptions of Etna? (*b*) Where is Etna?

28. What unusual phenomenon occurred at the eruption of Mont Pelée.

29. What was the character of the eruption of Mount Katmai? Where is Mount Katmai?

30. For what is the recent eruption of Lassen Peak notable?

31. (*a*) Give three evidences of past volcanic activity in eastern United States. (*b*) Why are there no volcanic cones there?

32. Explain the difference between an intrusion of lava and an extrusion.

33. Using a diagram, explain the difference between a lacolite, a sill, a dyke.

34. How are lava plains formed?

35. (*a*) Describe the Columbian lava plateau. (*b*) How is it shown that the lava flows in this region were intermittent? (*c*) Locate this flow on Figure 135.

36. Compare Vesuvius, Italy, with Mauna Loa, Hawaii, accounting for differences in mode of eruption, character of ejected material, and form of cone.

37. Name three kinds of material ejected from volcanoes, and account for their physical differences.

38. (*a*) What is an earthquake? (*b*) How are they explained? (*c*) What kinds of destructive effects are observed?

39. (*a*) Describe the Ischian earthquake. (*b*) What direction did the force seem to have?

40. What was learned by the study of the Charleston, South Carolina, earthquake?

41. (*a*) What caused the San Francisco earthquake? (*b*) The Messina earthquake?

42. Where was the most recent earthquake of which you have heard?

43. Describe the distribution of earthquakes.

44. What causes the sea waves that often follow earthquakes?

45. How does the velocity of the earthquake wave aid us in determining conditions in the interior of the earth?

CHAPTER XXV

SHORE LINES AND HARBORS

1. Recall the facts about the continental shelf, pages 227–229.

2. Define *coast, shore, shore line, beach.*

3. What is meant by the seaward migration of a shore line?

4. Mention two agents that sometimes transport rock waste and form a sandy beach.

5. How does rock waste make a shore line more regular?

6. What other action provides the rock waste that forms certain beaches?

7. Describe the formation of the regular shore line at Nome, Alaska (Figure 322); at Wellfleet, Massachusetts (Figure 323); at Island Beach, New Jersey (Figure 329); at Asbury Park, New Jersey (Figure 324).

8. (*a*) Compare the depth curves in Figure 322, and state which curve shows the most effective smoothing action of the waves. (*b*) In what way does Figure 325 confirm your conclusion?

9. Using a diagram explain how bay-mouth bars are formed.

10. Describe the formation of an offshore bar.

11. (*a*) What are fault-plane shores? (*b*) Why are they regular? (*c*) Locate three examples.

12. (*a*) What made the mainland shore line of eastern United States irregular? (*b*) Name three large bays and three minor irregularities in it.

13. How was the irregular coast of northwestern Spain formed?

14. (*a*) Describe the Maine coast. (*b*) What made it irregular?

15. What are fiords, and how were they formed?

16. Describe a fiord shore line.

17. Locate and describe a shore line due to mountain folds parallel to the shore.

18. How was San Francisco Bay formed?

19. Why is the northwestern coast of North America irregular?

20. (*a*) What is a fringing reef? (*b*) A barrier reef? (*c*) Give an example of each.

21. (*a*) What is an atoll? (*b*) How are coral reefs formed?

22. Name four harbors that have influenced the spread of civilization, and explain.

23. Define *haven, harbor, port of entry.*

24. State the requirements of a good harbor.

25. (*a*) How is New York Harbor protected from storm waves? (*b*) From the winds?

26. Mention other advantages of New York Harbor.

27. What are its disadvantages?

28. Name other important submerged valley harbors.

29. State the disadvantages of some of them.

30. Describe and locate a lagoon harbor.

31. Locate an island harbor.

32. Name five artificial harbors.

33. What natural agents tend to destroy harbors?

34. Name five important coast cities, and classify their harbors as to origin.

35. (*a*) In what respect does the Golden Gate of San Francisco Harbor resemble the Narrows of New York Harbor? (*b*) How do they differ in structure?

36. Under what conditions are floating docks used in harbors?

37. Are the docks of New York Harbor parallel to or at right angles to the shore line?

38. (*a*) State the advantages and disadvantages of docks parallel to the shore line; (*b*) of docks at right angles to the shore line.

39. What are the requirements of a good air port?

PICTURE STUDIES

FOUCAULT'S PENDULUM EXPERIMENT

FIGURE 6

In the picture nearest you place *S* for south, and then place in proper position *N*, *E*, and *W*. Place arrows on the floor in the picture to show the direction of the movement of the floor under the pendulum. Keep in mind that in the northern hemisphere the southern side of a room moves east faster than the northern side. — F. L. B.

STUDY OF THE STAR TRAILS

FIGURE 8

1. The north sky pole is about a degree and a quarter from the North Star. Using the trail made by the North Star, carefully locate the sky pole.
2. Knowing that the earth rotates 15° an hour, make an estimate of the number of hours the photographic plate was exposed to produce these star trails.
3. How many degrees above the horizon is the sky pole in latitude 43° 45′ where this photograph was taken?
4. Select two or three of the longer and brighter trails at different distances from the sky pole, and measure the angle between lines drawn from each end of trail to the sky pole. Do you find the angles the same? What does this prove?
5. Account for some of the trails being brighter than others. — F. L. B.

THE EARTH IN ITS ORBIT

FIGURE 10

1. Use the aphelion and perihelion distances given in the figure, and calculate the average distance of the earth from the sun.

2. Make a drawing to show the illumination of the earth at a position midway between the winter solstice and the vernal equinox.

3. Try to indicate on this drawing the size of the sun and earth, if they should be drawn in accordance with the scale that has been used. — F. L. B.

SKY PATHS OF THE SUN AS SEEN AT THE EQUATOR AT CERTAIN DATES

FIGURE 11

1. Judging from the position of the sun paths at the equator at all times of the year, during what two seasons in the north would the highest temperatures be most likely to occur at the equator?

2. Give the direction of sunrise and sunset at the four dates specified in the drawing.

3. Between what dates should the sun shine into north windows of a house located on the equator? Into south windows?

4. At what time of day approximately at all times of the year does the sun rise and set at the equator?

5. On what dates only is the noon sun directly overhead? — F. L. B.

SKY PATHS OF THE SUN AS SEEN AT NEW YORK AT CERTAIN DATES

FIGURE 12

1. Compare the length of day on June 21 with the length of day on December 21 as shown in the drawing.

2. What is the direction of the midday sun from the zenith at all times of the year?

3. At what date is the noon sun highest in the sky? How many degrees does it lack in reaching the zenith in your latitude?

4. A house on June 21 located at 0, Figure 11, would receive in north windows direct sunlight for the entire day. Compare the direction of direct sunlight received in the windows of a house similarly placed in Figure 12.

5. The noon sun at the date of the equinoxes is how many degrees from the zenith? Compare this with the latitude. — F. L. B.

SKY PATHS OF THE SUN AS SEEN AT THE ARCTIC CIRCLE

FIGURE 13

1. In what direction is sunrise and sunset on June 21? How long is the day on this date?
2. At what time of day does the sun touch the horizon? What is meant by the "Land of the Midnight Sun"?
3. At what date does the sun touch the horizon at midday? Explain.
4. Give an approximate date when the day would be 23 hours long with only one hour night?
5. Give reasons why the summer at the Arctic Circle may be expected to be short in duration and high in temperature. — F. L. B.

SKY PATHS OF THE SUN AS SEEN AT THE NORTH POLE

FIGURE 14

1. The sun path at the time of the equinoxes coincides nearly with what circle?
2. How long does it take the sun to reach its highest position in the sky? To return to the horizon? How long then is the period of continuous sunlight?
3. At what time of the year might the sun be said to rise? To set?
4. By noting the position of the sun continuously for twenty-four hours, how could an observer prove his position to be at the north pole?
5. From a vertical position of the sun paths at the equator to a horizontal position at the poles, the paths have been tipped through how many degrees? What relation does the amount of inclination of sun paths always bear to the latitude of the observer? — F. L. B.

APPARENT MOTION OF THE STARS NEAR THE NORTH POLE

FIGURE 16

1. At latitude 40° north what is the altitude of the North Star when it is directly above the north celestial pole? Directly below?

2. What is the altitude of the north celestial pole at the terrestrial equator? The north pole?

3. In what direction are circumpolar stars moving when below the north sky pole? Above it? — F. L. B.

THE SUN DIAL

FIGURE 19

1. What time of day is indicated on the sun dial? What kind of time is this?

2. By consulting the *Nautical Almanac* for the equation of time for a certain date, how would you check up the reading of the sun dial so as to get mean solar time? — F. L. B.

TIME BELTS OF THE UNITED STATES

FIGURE 21

1. What is the time of day in the greater part of Florida now as compared with the time there before the adoption of the new position of the boundaries of the standard time belts?

2. Point out cities where the time of day has been advanced one hour.

3. Where may places be located giving cities a choice of two standard time belts?

4. What advantages has the new location of time belt boundaries over the former location? — F. L. B.

TOPOGRAPHY OF THE MOON

FIGURE 22

1. Make an enlarged drawing of a ringed valley with a volcanic cone built up at the center. Two or three examples of this kind may be seen.

2. Notice the shadows cast by the rims of the ringed valleys. What does the length of the shadows indicate? — F. L. B.

ECLIPSE OF THE SUN

Figure 27

1. What sometimes hides the surface of the sun? Is this darkening of the sun real or apparent? About how long does it last?

2. About how long are the streamers of light from the sun as compared with its diameter?

3. Notice the red flames in the corona. How much, according to your estimation, does the height of these flames extend from the photosphere? — F. L. B.

SUN SPOTS

Figure 28

Sun spots are holes in the visible surface of the sun that are sometimes several thousand miles deep. The diameter of the larger of the two shown in this figure probably exceeds the diameter of the earth.

The picture is most interesting. It is the first to show so much detail of a sun spot, and leads to much speculation.

Some observers maintain that sun spots are cyclonic storms, and in support of their claims point out the close resemblance of the curved lines above and below the two sun spots, shown in the figure, to a map of the course of the winds about a low-pressure area in the northern hemisphere of the earth. It is difficult on this theory, however, to explain the lines which are noticeable between the two sun spots.

Notice the raised rim around each of the black spots. Does this prove or disprove the cyclone theory?

We know that sun spots affect the magnetic condition of the earth, and these two sun spots seem to indicate that there is something else magnetic about them.

The picture of them might very easily be mistaken for a print showing the magnetic lines of force above the poles of a horseshoe magnet.

If it could be shown that the two sun spots were really the poles of a magnet, it would also explain certain other features shown in the photograph.

CONTACT OF MANTLE ROCK AND BEDROCK

FIGURE 113

This picture represents the upper part of a small ravine. The bedrock is limestone.

1. Note the line that separates the consolidated rock from the loose material above it. This is the line of contact between the bedrock and the mantle rock.
2. Describe the mantle rock, giving an estimate of the sizes of the largest and the smallest particles shown.
3. Are the exposed edges of the bedrock more like those of Figure 114 or like those of freshly broken stone?
4. How many vertical cracks can you count in the top layer of limestone?
5. What name is given to the dark band just below the surface of the ground? — A. L. A.

CHARACTERISTICS DISPLAYED BY THE AGENTS OF WEATHERING

Before studying specimens or pictures of weathered rock, let us recall some of the distinguishing characteristics of rocks weathered by the different processes.

1. *Change of temperature* causes thin layers of rock to break off leaving miniature cliffs where a portion of the layer still adheres to the bowlder. This is called *exfoliation.*
2. *Freezing and thawing.* When water freezes in a *crack,* it enlarges the crack and tends to *split* the rock. When freezing occurs in the pores of a rock, it breaks off *flakes or chips* of the rock.
3. Wind-blown sand usually undercuts rock leaving a smooth surface.
4. Plant roots growing in cracks, *split* rocks.
5. Chemical action corrodes rock wherever the chemical touches it. Rain water contains dissolved oxygen and carbon dioxide. It wets the exposed surface of a rock cliff and circulates through joints and fissures and pores of the rock and along its bedding planes, thus attacking the corners and edges of every block or layer and slowly rounding corners and edges without leaving the ridges of exfoliate weathering.

EXFOLIATE WEATHERING

Figure 116

To follow the recitations on weathering, pages 264–270. — This bowlder was one of a large number of angular blocks that were formed when the internal stresses broke up a great mass of granite. Our problem is to find out how it became a spheroidal bowlder.

1. What physiographic process does this picture illustrate?
2. What physiographic agents may have been active in forming the feature shown?
3. What conditions made the work of these agents possible?
4. Mention any minor feature noticed on the bowlder.
5. What evidence do you see that layers of the bowlder have scaled off?
6. What processes of weathering cause scaling?
7. How many parts of scaled-off layers can you count?
8. Why are they about the same thickness?

Interesting point to be discussed if there is time to spare. — One naturally wonders that the removal of scales of about the same thickness did not leave the block in its original form, but smaller. The reason is that the *corners* of an angular block exposed to sunlight or even to warm air would be heated on *three sides* at times, as shown in the sketch. This would heat the small mass of rock, forming the corner, to a higher temperature than the middle of the block could reach, thus causing greater expansion and quicker scaling. Figure A.

In the same way the *edge* of an angular block that is not covered by another block would be heated on two sides and would scale off. — A. L. A.

WEATHERING GRANITE

Figure 114

It has been well established that, while still covered by a thick layer of other rocks, the granite split into angular blocks, each of which fitted into place like the stones in a wall. Weathering did not affect these stones until the overlying rocks were worn away, so that the granite was exposed to the air or to surface waters.

1. Which of the blocks of rock show evidence of exfoliate weathering?

2. Explain why the lower side of these blocks is not weathered as much as their top sides.

3. Which of the above processes is the probable cause of the widening of the vertical joints? Give reasons. — A. L. A.

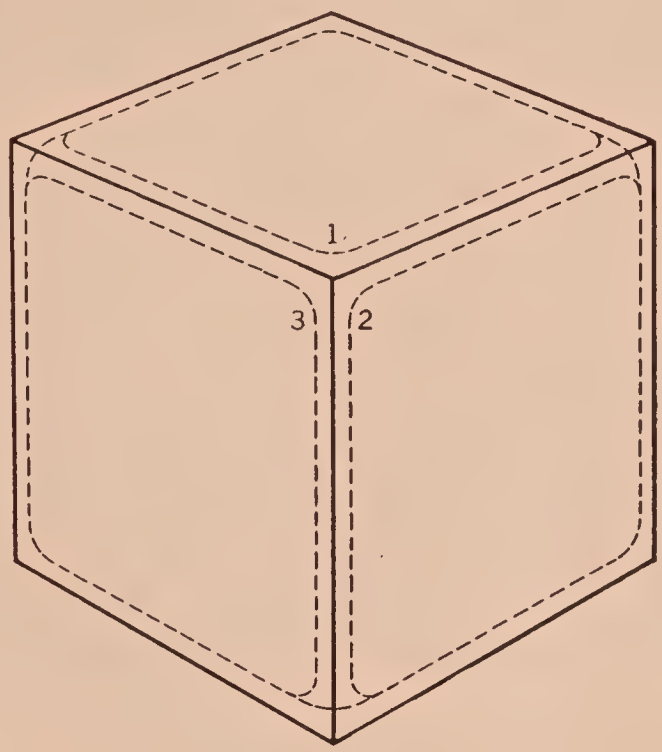

FIG. A

Effects of changes in temperature and chemical weathering on angular rocks.

WEATHERING LAVA

FIGURE 115

The Absaroka range, named for the Crow Indians, is just east of the Continental Divide in Wyoming. The lava shown is a part of a great lava flow that covered many hundreds of square miles of northwestern United States. In its original form the lava probably had a smooth upper surface, and the peculiar forms that terrified the Indians are the result of weathering.

In the deep valleys between these pinnacles, particles of lava loosened by weathering begin their journey to the Gulf of Mexico. Some of them have paused for a while at the foot of the cliff, forming a steep pile of rock waste known as a *talus slope*. (See page 283.)

Because of its elevation (12,000 feet) these mountains have abun-

dant precipitation and supply water to two important tributaries of the Yellowstone River.

1. Compare the weathered lava with the weathered granites of Figures 114 and 116.
2. Examine the figure for blocks of lava that have fallen from the cliff, and for places from which other blocks have been removed.
3. Note the deep but narrow valleys cut in the upper portion of the lava. How many of them can you find?
4. Account for the rills (little water courses) on the talus slope, that lead from points directly below each of the deep valleys to a larger water course, the group resembling a trunk stream and its tributaries.
5. What substance is present in rain water that makes it active in weathering igneous rock?
6. What name is given this process of weathering?
7. When it rains, the sides and the bottom of the little valleys at the top of the lava are equally wet. Why, then, should not the valleys have been widened as rapidly as they were deepened?

Point of interest. The lava in this figure, like most lava, is without joints. Why was it not broken like the granite of Figure 114? — A. L. A.

WEATHERING ABOVE THE TIMBER LINE

Figure 117

The building here shown is a station of the United States Weather Bureau, on the top of Pike's Peak, 8000 feet above the plains at the base of the mountain.

The broken rock on top of the mountain is not covered with soil, because rock waste is carried away by rain, melted snow, and winds about as fast as it is formed. At lower levels there are talus slopes.

1. Are the rocks of this picture angular or spheroidal?
2. Which agents of weathering produce rounded forms?
3. Which angular?
4. Of those mentioned, which probably broke up this rock? Pike's Peak is just the right height to permit daily freezing and thawing at certain times of the year.

Whenever the daily average temperature is 60°F. at its base, the day and night temperatures will be 33° and 27° respectively.

Recall the vertical temperature gradient and compute the average

daily temperature 8000 feet above a plain when the average temperature at the base is 60°F. At an elevation of 8000 feet the day and night temperatures would differ by about 6°.

WEATHERING ROCKS OF UNEQUAL RESISTANCE

FIGURE 119

The rounded masses on top of pedestals are called *concretions*. They are formed of materials deposited by water that circulates through crevices or the pores of bedrock, page 377.

Concretions differ from the surrounding rock in composition and resistance to the action of the agents of weatherings.

1. Point out the concretions.
2. Which rock is least resistant to weathering; that of the concretions, that of the layer containing the concretions, or the layer near the ground?
3. Which of the three is most resistant?
4. Which of the agents of weathering produce an uneven surface and which a smooth surface?
5. Which of the above agents could not have formed the pedestals that support the concretions.

Another illustration of unequal weathering is seen in Figure 118. Certain of the layers stand out in relief because more resistant. Account for the holes in the side of the middle outlier. — A. L. A.

STUDY OF A GULLY IN MANTLE ROCK

FIGURE 202

To precede the first lesson on stream erosion. — All books open to Figure 202.

In the foreground of this picture, you will see just beyond the fence a small stream that curves around a valley flat on the farther side of the stream. Beyond this flat land is a steep slope that rises ten or twelve feet to a second gently sloping field. We thus have a steep slope between two gentle slopes.

One day, after a heavy shower, the owner of the upper field found that a portion of his land had been washed away.

1. Place your pencil points on the land that was washed out.

2. Locate the place from which the materials came. The *notch* from which the soil was removed is called a *gully*.

3. On which of the three slopes should you expect the soil to be carried away most rapidly at first? Give your reason.

4. Why did the running water remove the soil from one place and deposit it at another?

5. What effect do such gullies have upon the value of the field? Why?

6. Is there any way of preventing further deepening of the gully? (See page 403.)

7. Compare Figures 202, 239, and 240, each of which shows an alluvial cone, and determine which of them has a fan-shaped base.

8. If a cone is a pyramid with a circular base, which of the three figures shows the best cone?

9. Are they cones or half-cones?

These cones or half-cones were formed by running water that eroded the soil, transported it a short distance, and deposited it, thus illustrating the work of all streams.

Running water is not the only agent that forms conical piles of mantle rock; in fact, this is the natural form assumed by all loose materials dropped in a given place, whether it be grain issuing from an elevator spout, a carload of coal dropped through a trestle, or the material of a landslide at the foot of a mountain. — A. L. A.

AUSABLE CHASM, NEW YORK

FIGURE 206

The rock walls of Ausable Chasm are Potsdam sandstone, one of the most durable rocks known. In some exposures the sand grains forming this rock are so firmly cemented together that the rock has very little porosity, and is sometimes called a quartzite.

1. What processes were concerned in forming the chasm?

2. What physiographic agent or agents have been active in the past?

3. What agents are now active?

4. State the relation between the constructive and the destructive processes that have affected the region illustrated.

5. What human interests have been affected by the changes suggested by this picture?

Figure B shows the relative levels of the chasm, Lake Champlain,

and the Atlantic Ocean. The horizontal distances between the points mentioned are not indicated in the sketch. *C* is the shore of the lake, and the line *CD* is the level of the lake. The zero line is the level of the ocean.

6. Has the river accomplished its work through abrasion of solution of the bedrock? Recall the solubility of sandstone.

7. How does the present velocity of the river compare with its velocity when it began to erode the chasm?

8. To what level can the river erode its valley?

The level at which erosion ceases is called *base level.* (See page 499.) The level of Lake Champlain is a *local base level* for the region that is drained into the lake and limits the erosion of all rivers that flow into it.

Sea level is a *continental base level* and limits the erosion of all rivers that flow into the sea, thus preventing further lowering of the continents by this process.

9. What area in the figure represents the total work that Ausable River can do?

10. What characteristics give Ausable River its great eroding power?

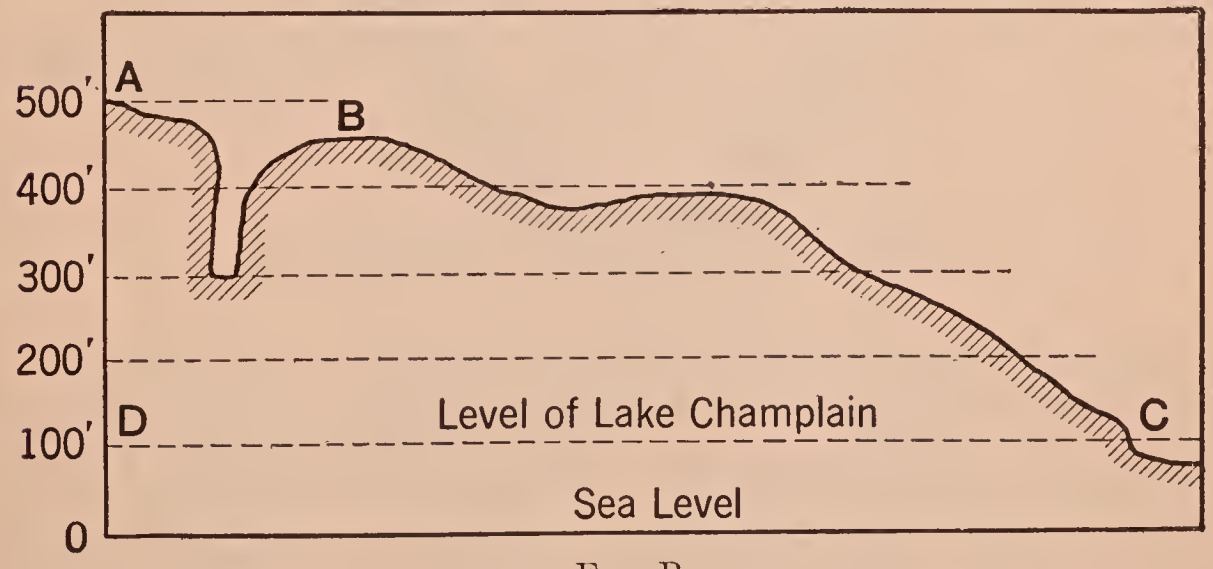

FIG. B

Section of Ausable Chasm.

WEATHERING CANYON WALLS

FIGURE 226

1. Is this a single fall or a series of falls?
2. Can you find four falls?
3. Is this a swift or a sluggish stream? How do you know?

4. What does the rounded form of these bowlders indicate?

5. If the stream had ability to transport them to this point, why did it drop them here?

6. Are they likely to remain here permanently? Why?

7. How did they assist in eroding the bed of the stream?

8. Where did the soil on the slopes come from?

9. Can you see any evidences of weathering, such as talus slopes, fragments of rock on ledges, etc.?

10. Is this a canyon or a V-shaped valley?

Figure *C*. Diagram of work of erosion of bed and of weathering. In the diagram let the lines 5, 2, 3, 6 represent the space excavated by erosion of bed and the triangles 1, 2, 5 and 3, 4, 6, the portion removed by the agents of weathering.

11. If the width of the stream 2, 3 is equal to the lines 1, 5 and 6, 4, how would the work done by erosion of bed compare with that done by weathering? — A. L. A.

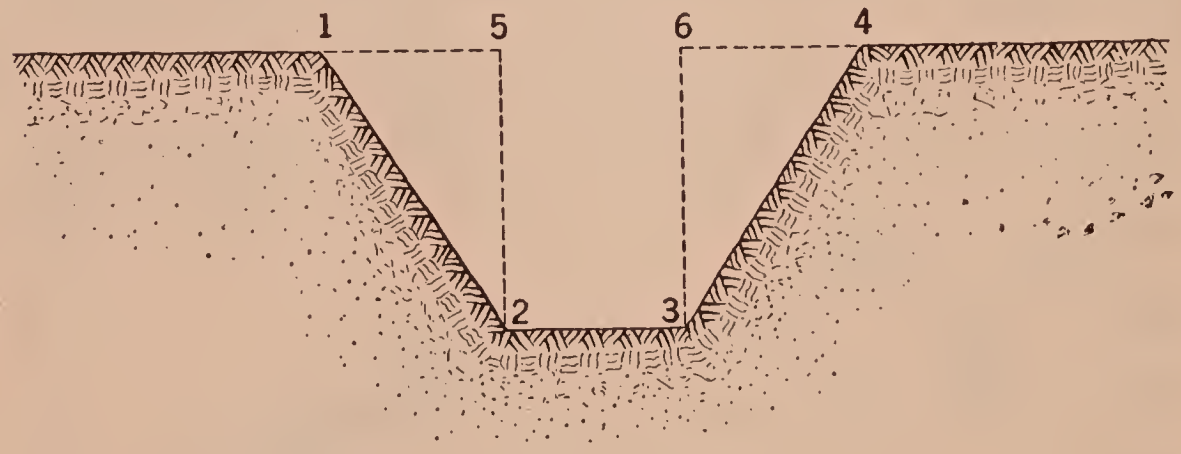

Fig. C

Relation between erosion and weathering.

ANCIENT LAKE BONNEVILLE

Figure 273

The region about Great Salt Lake is often called the Great American Desert, but it has not always been arid. Examination of the deposits that form the level surface shown in the picture reveals the fact that they accumulated on the floor of a lake. The shore line of this lake is found high up on the slopes of the mountains that surround the basin, and has been traced hundreds of miles by the

beaches, sandbars, and deltas formed when the basin was filled with water, indicating that a lake nearly as large as Lake Superior and 1000 feet deep once covered this arid region.

1. What three physiographic features are shown in Figure 273?
2. What is the rainfall in the Great Basin? (See pages 201 and 213.)
3. Recall the history of Great Salt Lake. (See page 201.)
4. State the cause of the present arid condition in this region. (See page 449.)
5. What climate would you expect if there were no mountains on the west of the basin?
6. During the glacial period (page 474) the climate in this region was colder and the precipitation greater than at present. The surrounding mountains were snow capped, and great glaciers were formed, some of which extended from the top of the Wasatch Mountains to the shores of Lake Bonneville. Briefly state the conditions that made Lake Bonneville possible.

Point of interest. — The water of Great Salt Lake contains so much salt that a bather does not sink. Thousands of barrels of salt extracted from the water are sold yearly.

7. The deposits formed in the lake contain two layers of rock salt separated by layers of lacustrine deposits. What changes of climate does this indicate?

STANDARD TIME BELTS AND THE INTERNATIONAL DATE LINE

The process of computing the standard time of different time belts at the same instant is simpler than that of computing the mean solar time of different cities, and results in just as clear ideas of the relation between longitude and time. For the purposes of this exercise we have, therefore, assumed that the Standard Time System, adopted by the United States in 1883, has been extended to all parts of the world.

The fact that the earth rotates through 360° in 24 hours, or 15° an hour, and one degree in four minutes, enables us to compute the difference in the times of any two places when we know the difference in their longitudes, or to compute the difference in their longitudes when we know the difference in their times.

Nearly all good globes have meridians drawn 15° apart, and the mean solar times of these meridians therefore differ by exactly one

hour. These 24 meridians are taken as the central meridians of the time belts, each of which extends $7\frac{1}{2}^\circ$ each side of its meridian.

Since the earth rotates toward the east, these meridians pass under the vertical rays of the sun at intervals of one hour each meridian, having its noon one hour *later* than the meridian next *east* of it, and one hour *earlier* than the meridian next *west* of it.

If such a globe as that mentioned is available, the determination of the difference in time between any two places is simply a matter of counting the number of meridians between them, allowing one hour for each belt.

In the absence of such a globe, the diagram below may be used in the same way. It represents the earth as seen from directly above the north pole.

The large circle is the equator, which is divided into 24 parts, each being 15° wide and representing about 1000 miles at the equator.

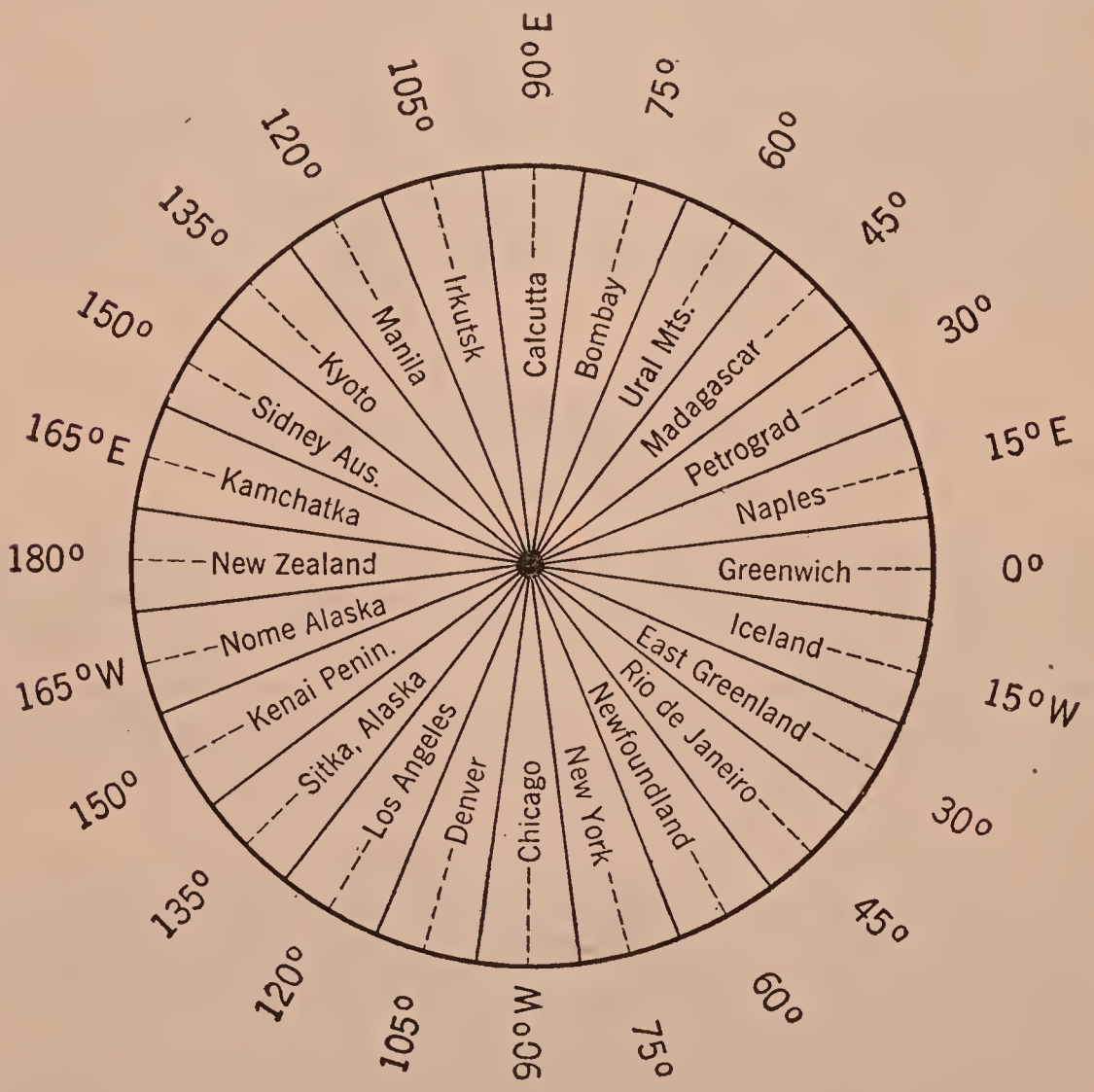

Fig. D

The dotted lines are the central meridians of the time belts, and the full lines are the boundaries of the different time belts.

Arrows indicate the direction of rotation of the earth. — A. L. A.

We can determine differences in time or in longitude with this diagram just as we can with the globe.

Suppose we wish to find the standard time at Naples, 15° east longitude when it is noon in Chicago, 90° west longitude. We place our pencil on the meridian 90° west and *say 12 noon;* on the next meridian east, 1 o'clock P.M.; then 2 P.M.; and so on to 7 P.M. at Naples the answer.

Problems

1. What is the standard time at 105° west longitude when it is noon in London?
2. What is the standard time in Calcutta, 90° east longitude, when it is noon in London?
3. What is the standard time in Sidney, Australia, 150° east longitude, when it is noon in London?
4. What is the standard time at 135 east longitude when it is 9 P.M. in London?
5. What is the standard time at Nome, Alaska, when it is noon in New York City?
6. What is the standard time in Iceland when it is noon in the Canary Islands, 15° west longitude.
7. What is the longitude of the meridian on which it is 3 A.M. the same day when it is 8 A.M. in New York?
8. In what longitude is it 3 A.M. the next day when it is 12 o'clock noon in New York?
9. When it is 5 o'clock A.M. in New York, what is the longitude of a place having 1 o'clock A.M. the same day? What that of a place having 11 P.M. the previous day?
10. When it is noon by the ship's local time and the ship's chronometer carrying London time shows 9 o'clock P.M., what is the longitude of the ship?
11. What is the standard time at Kyoto, Japan, 135° east longitude when it is 8 o'clock P.M. in Denver, Colorado? (Count toward the east, and state the hour and day.)
12. Solve the eleventh problem counting toward the west, and state the hour and day. Why do you not get the same answer?

By common consent it is agreed that a given date shall appear upon the earth for the first time when the 180th meridian reaches its midnight position. This meridian is called the *date line.*

If we let the diagram, Figure D, represent the 180th meridian in its midnight position and call the new day that is just beginning March 1, 1928, we shall see that the next meridian to come to the midnight position is the 165th, east longitude, which begins its March 1 an hour later than the 180th meridian, and that the meridian of London will begin this date twelve hours after the 180th did so. How long after the 180th meridian began its March 1 will the 165th meridian, west longitude, begin its March 1?

Is it true that the times of these two adjoining time belts differ by 23 hours?

If you cross the date line in a direction opposite to that of the rotation of the earth while counting time belts, you will find it necessary to add 24 hours to the time just as ships do when they cross it in the same direction.

If you count across the date line in the same direction as the rotation of the earth, you will have to subtract 24 hours from the time.

Remember these two points, and you will get the same answer whichever way you count.

TO DETERMINE THE LATITUDE OF A PLACE

In ancient times latitude was quite accurately determined from observations of the gnomon mentioned on page 7. The method used was to compute the angle on June 21 between the sun's rays, and a vertical line, by measuring the length of the shortest shadow of the year. The ancients knew that the angle between the sun's ray and the gnomon, Figure 2, was equal to the angle at *C*, which is the same as saying that measuring the length of the shadow will tell you the angle at the center of the earth between the sun's vertical ray and the line from the observer to his zenith.

Six months later, when the sun cast its longest shadow, they computed the angle again, and the average of these angles gave them the latitude of the place.

With a sextant, page 28, when all corrections are made, the position of a ship may be determined within half a mile. With the great transits of our observatories latitude is determined with very much greater accuracy.

For our purpose the principle used by the ancient astronomers is chosen, because it eliminates two of the larger corrections, because the apparatus is simpler, and because *it measures the zenith distance of the sun directly, not its noon altitude.*

A miniature gnomon can be made of a half-inch brass rod about 14 inches long fastened to a circular base at the exact center of the circle. The brass rod should have a sharp point at the upper end.

When ready to perform the experiment, place a table in a south window or out of doors, adjusting it so that the top is perfectly level.

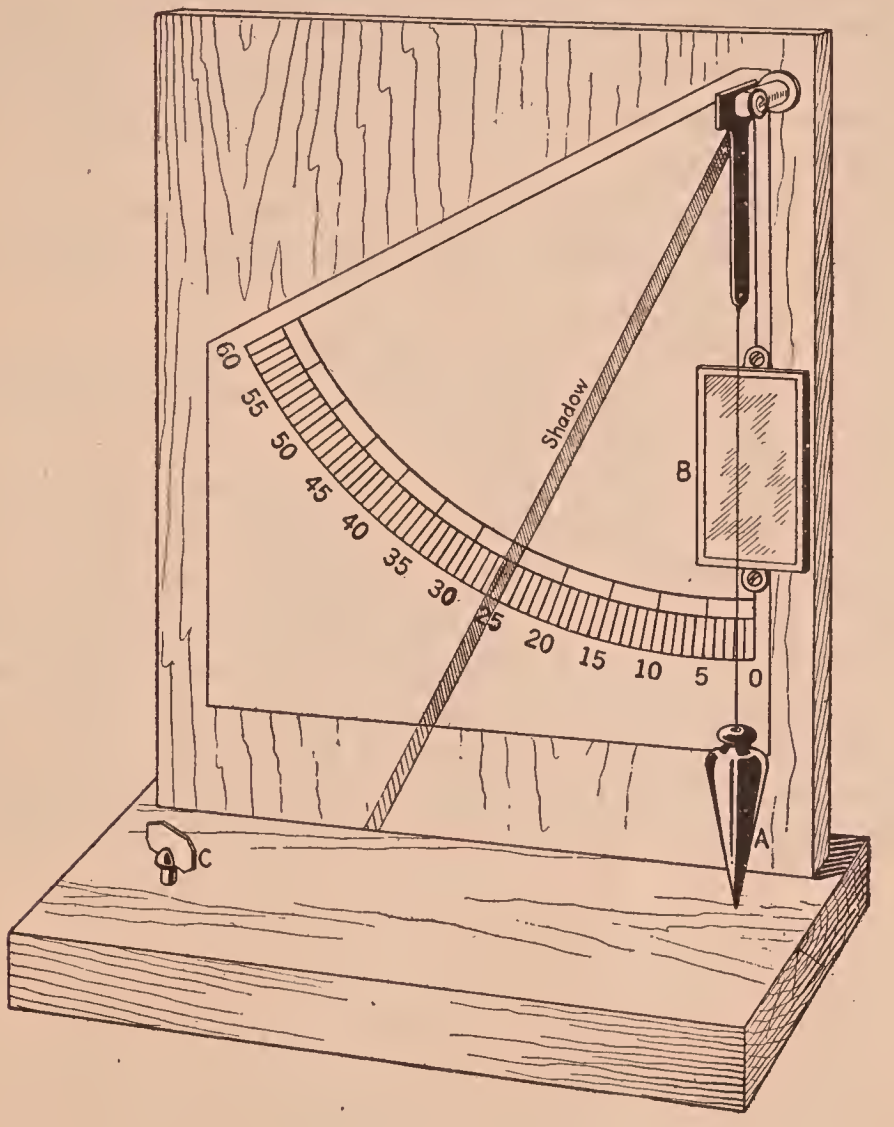

FIG. E

A, plumb bob: *B*, mirror: *C*, screw for levelling base. Arey apparatus.

Then place a large sheet of paper on the table, fastening it with thumb tacks.

Place the gnomon near the center of the window side of the paper, and draw a pencil line around the base of the gnomon as close to the base as possible.

Beginning about 15 minutes before solar noon, mark the exact position of the shadow of the point of the gnomon; repeat this every two minutes until about 15 minutes past solar noon.

Draw a smooth curve through the points located, and determine what point in the curve marks the shortest shadow. Measure the distance from this point to the circle drawn about the base of the gnomon, and add to it one-half the diameter of the circle. This sum is the length of the shortest shadow for the given date.

Now measure the exact height of the gnomon, and construct the triangle formed by the sun's ray, the gnomon, and the shadow.

On the triangle measure the angle at the point of the gnomon with a protractor reading to at least 15′. This is the zenith distance of the sun at solar noon.

Now note whether the shadow of the gnomon was on the south or the north side of the gnomon. This will tell you whether the sun is south or north of you.

Consult the *Nautical Almanac* (or other almanac) for the sun's declination at the time of the observation, and compute the latitude of the place by the following rule:

If the sun is *between the observer and the equator,* his latitude is the sum of the zenith distance and the sun's declination; in all other conditions his latitude is the difference between these two quantities.

The Arey apparatus shown in the figure is easily constructed. It has the following advantages: It measures the zenith distance *directly.* The line casting the shadow is always horizontal. A set screw provides for the adjustment of the plumb line to the zero of the scale. It is not necessary that the surface on which the apparatus rests be absolutely horizontal.

Photographs of Physiographic Features

Photographs sixteen by twenty inches for classroom use may be obtained from the authors. The first set of ten is now ready. Other sets will be issued from time to time. A circular describing these sets may be obtained from the address below.

1. The River's Tools (*a study of erosion, Queechee "Gulf," Vermont*)
2. Recession of Falls (*Yellowstone Canyon*)
3. Lateral Erosion and Terraces (*Upper Snake River, Wyoming*)
4. Flood Plain and Meanders (*Valley of the Milk River*)
5. Mer de Glace (*an Alpine glacier*)
6. Glaciers of the Himalaya mountains (*A. Snow Field of the Tarim Sehr glacier; B. Great Saichen glacier*)
7. Parellel Joints (*three sets*)
8. Uplifted Sedimentary Rocks (*Mount Robinson*)
9. Telephoto of the "Top of the World" (*Mount Everest*)
10. Surf near Tillamook Head, Oregon

Suggestions as to the points that may be brought out by class discussion accompany each picture. Price $15 per set. Single pictures $2.00 each, postpaid.

Arey and Bryant,
Roslyn Heights, New York